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Washington, D. C. ▼ February, 1924

EXPERIMENTS WITH EMMER, SPELT, AND EINKORN

By

JOHN H. MARTIN and CLYDE E. LEIGHTY
Agronomists, Office of Cereal Investigations
Bureau of Plant Industry

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INTRODUCTION.

Emmer has been grown to a considerable extent in the United States during the past 25 years. Some spelt also has been grown. Both crops are now declining in importance, but some interest still is maintained by occasional high yields on farms or by exaggerated statements by promotors who have seed for sale.

Both emmer and spelt usually are referred to by farmers and seedsmen as "speltz." The names "Russian oats," "spelz," and "spiltz" also have been used. In Germany the two crops are referred to collectively as "Spelzweizen" (spelt wheats) and in Russia as "polba," although this means spelt. Emmer (*Triticum sativum dicoccum*) is known in Germany as "emmer" and in France as "amidonnier." Spelt (*Triticum sativum spelta*), is called "Spelt" or "Dinkel" in Germany and "épeautre" in France. As emmer and spelt are distinct crops, the word "speltz" should be discarded, and they should be known by their proper names.

CHARACTERISTICS OF EMMER, SPELT, AND EINKORN.

Emmer, spelt, and einkorn are distinct kinds of wheat, as is indicated by the different numbers of chromosomes in the cells. They are distinguished from other wheats by the fact that most of the kernels are not removed from the chaff (glumes) in threshing. In all three

NOTE.—The manuscript for this bulletin was submitted for publication May 18, 1923.

the rachis is fragile and breaks up during the threshing operation, leaving most of the spikelets whole. The segments of the rachis remain attached to the spikelets.

The kernels of emmer and spelt are somewhat similar. They are long, slender, and tapering (Pls. I and II). The kernels have a wide, shallow crease, angular flat cheeks, and a long pointed brush. The kernels of spelt are somewhat more flattened, have a wider, more open crease, and are somewhat less humped than the kernels of emmer. The kernels of both emmer and spelt are red in color and usually are semihard or hard in texture, the kernels of emmer usually being the harder of the two. The kernels of einkorn are also reddish in color, but are smaller than the kernels of spelt and emmer and are compressed laterally.

Recent studies indicate that einkorn, emmer, and spelt differ in the number of chromosomes. Sakamura (*36*)[1] states that einkorn has 14 chromosomes in the somatic cells, emmer 28, and spelt 42. He further states that *T. turgidum*, *T. durum*, and *T. polonicum* have the same chromosome number as emmer, and *T. vulgare* and *T. compactum* have the same number as spelt. Sax (*42*) has found the same chromosome numbers as reported by Sakamura. Kihara (*22*) reports that F_1 hybrids between members of the spelt and emmer groups contain 35 chromosomes in the somatic cells. Individuals of the F_2 generation varied from 31 to 42, while those of the F_3 generation varied from 28 to 41 in chromosome numbers.

Schulz (*44*) concludes, from a consideration of the botanical characters of the wheats, that einkorn, emmer, and spelt have had their origin from different wild species, and he classifies the wild and cultivated wheats into three lines or groups, according to supposed lines of descent.

Vavilov (*65*) divided the species of wheat into three groups on the basis of their reaction toward leaf rust, *Puccinia triticina* Eriks., and mildew, *Erysiphe graminis* DC. Einkorn, emmer, and spelt were in these separate groups, although there were some exceptions, both susceptible and immune strains of emmer being found.

Zade (*70*) likewise divides the wheats into three groups on the basis of his serological studies, einkorn, emmer, and spelt being again in the separate groups.

It is apparent from the various studies that have been made that einkorn, emmer, and spelt belong to what may be considered as different species of wheat. There is a further difference in the adaptation between the emmers and spelts grown in the United States. Spelt is better adapted to humid regions, being comparable to soft red winter wheat in this respect, and emmer is better adapted to regions of lower rainfall, being comparable to durum and hard red winter wheat.

CHARACTERISTICS OF EMMER.

Emmer usually has pithy culms and pubescent leaves. The spikes are very dense and laterally compressed, being narrow when viewed from the face of the spikelet and wide from the edge view (Pl. I). The pedicel (joint of rachis) is short, narrow, and pointed and usually remains attached to the spikelet which it bears. The spikelets are flattened on the inner side. They usually contain two (or sometimes

[1] Serial numbers (*italic*) in parentheses refer to "Literature cited," at the end of this bulletin.

three) flowers. Both bearded and beardless and winter and spring varieties of emmer are known, although no variety of beardless emmer is grown commercially in the United States. Some varieties of emmer are quite resistant to rust. The winter hardiness and drought resistance of emmer have been much overestimated by Carleton (*7*, *8*) and others.

CHARACTERISTICS OF SPELT.

Spelt usually has hollow culms and glabrous or slightly pubescent leaves. The spikes are long, slender, and lax. The spikelets are far apart and arched on the inner side (Pl. II). The pedicel (joint of rachis) is long and wide and after threshing usually remains attached to the face of the spikelet below the one which it bears. Both bearded and beardless and winter and spring varieties of spelt are known. The winter varieties usually will produce seed from spring sowing unless sown very late. Most varieties are rather tall.

Emmer can be distinguished easily from spelt by its compact spikes and by the short, narrow pedicel, which usually is attached to the base of the spikelets of the threshed grain.

CHARACTERISTICS OF EINKORN.

Einkorn (*Triticum monococcum* L.) is very distinct from emmer and spelt in having very narrow, slender spikes. The spikes are awned and laterally compressed, and the terminal floret usually is sterile (Pl. III). The kernels remain in the glumes when threshed. They are pale red in color, small, slender, and very much compressed laterally. The common einkorn contains but one kernel in each spikelet, but the double einkorn contains two kernels. The name "einkorn" is of German origin and means "one grained." In French it is called "engrain."

The plants of einkorn are late in maturing. The stems are slender and short, making harvesting with the grain binder difficult. It is of no economic value in the United States and is grown only in very limited experiments.

HISTORY.

Emmer is of very early origin. De Candolle (*5*) states that it has been found among the ruins of the lake dwellers of Switzerland. Snyder (*51*) reports having received from Egypt a sample of emmer kernels which were nearly indentical with the kernels of Vernal (White Spring) emmer grown in Minnesota. Reports considered authentic by that author, in regard to this sample, indicated that it was removed from the interior ruins of an Egyptian pyramid which had been built about 3,700 years ago.

That emmer was grown by the Romans previous to the Christian era is indicated in the writings of Varro, Pliny, and Columella (*13*), who mention a form of Triticum (wheat) called "adoreum" or "far," which was not separated from the chaff in threshing. The wild emmer (*Triticum dicoccum dicoccoides*) found on the slopes of Mount Hermon, in Syria, may or may not be the prototype of our cultivated varieties of emmer. A rather primitive-appearing cultivated variety of emmer, Khapli or Kathiawar, described later, has been obtained by the United States Department of Agriculture from India, where it is said to grow wild also.

Love and Craig (*26*) report the appearance of a wild type of wheat in the progeny of a cross between durum and common wheat. The segregates of this type were similar in all respects to the typical wild wheat of Palestine. This occurrence of the wild form may be considered either as evidence that the wild wheat of Palestine is the prototype of cultivated emmer or that this wild form has arisen through natural crossing between already existing forms.

Emmer apparently was introduced into the United States by German immigrants from southern Russia who settled in the Dakotas. Carleton (*8*) states that it "was known to northwestern farmers probably as early as 1875 or 1880." More recently several lots of emmer, mostly from Russia and Germany, have been introduced and distributed by the United States Department of Agriculture.

Spelt probably is of later origin than emmer. Considerable doubt exists as to its cultivation by the Egyptians, Greeks, or Romans. It is known, however, to have been grown in Europe and Asia for more than 200 years. Spelt has been introduced into the United States on numerous occasions, several introductions having been made during the nineties. It was grown experimentally in California as early as 1893. More recently samples of spelt have been received by the United States Department of Agriculture from Germany.

Einkorn probably is of more ancient origin than either emmer or spelt, and it is mentioned in very early writings. It apparently has never been extensively cultivated and is now grown sparingly on poor and stony slopes in the countries of southwestern Europe. Several introductions of einkorn from France, Germany, and Turkey have been made during the past 20 years. These lots have been grown in experiments in this country, mostly in nursery rows, but the crop has not become commercially established.

DISTRIBUTION.

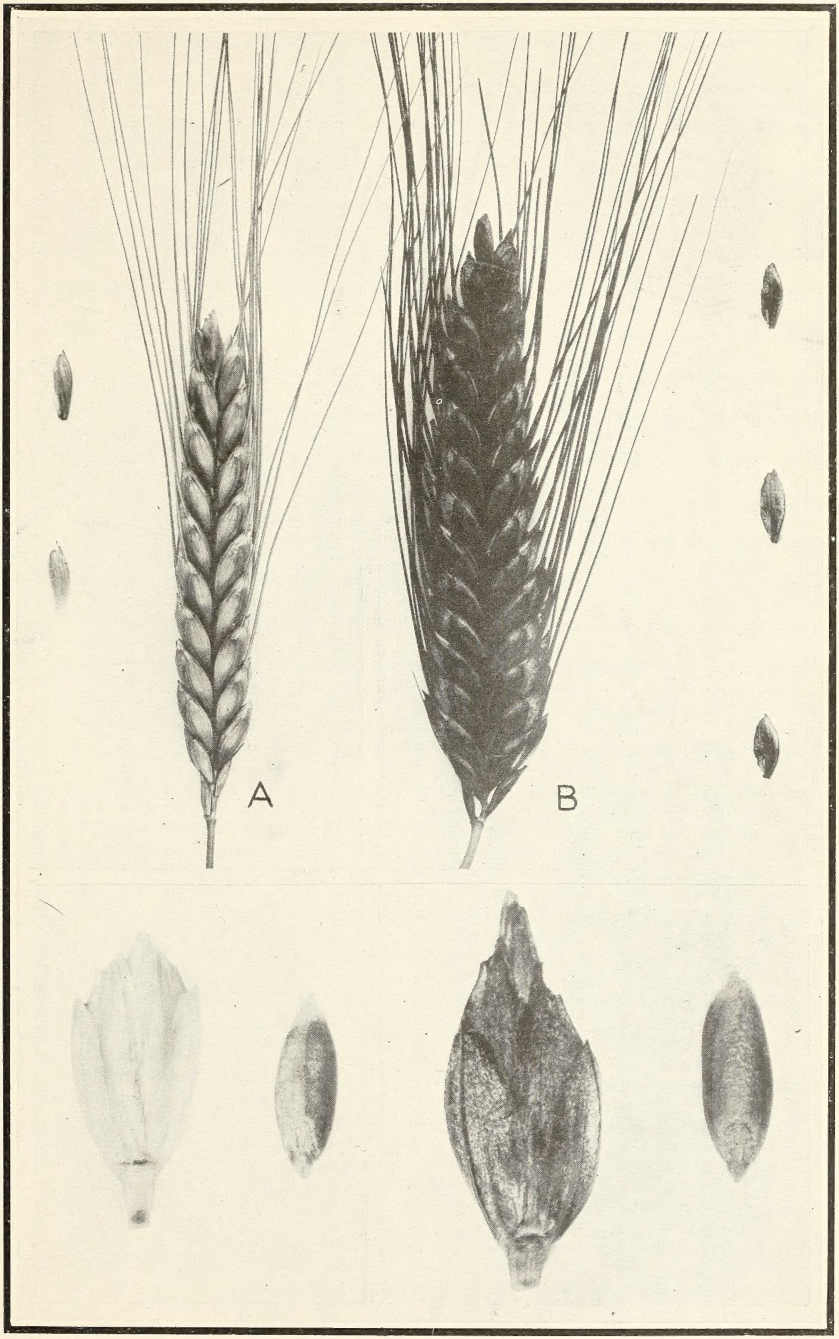
Emmer is known to be grown in Russia, Germany, Serbia, Austria, Spain, France, Italy, Switzerland, Persia, India, and Abyssinia, as well as in the United States and Canada. It is generally of greater relative importance in regions of low rainfall and unfavorable growing conditions.

Spelt is grown less widely and is of less importance than emmer in the countries where it is found. It is known to be grown in Germany, France, Switzerland, and Serbia, and to a slight extent in the United States.

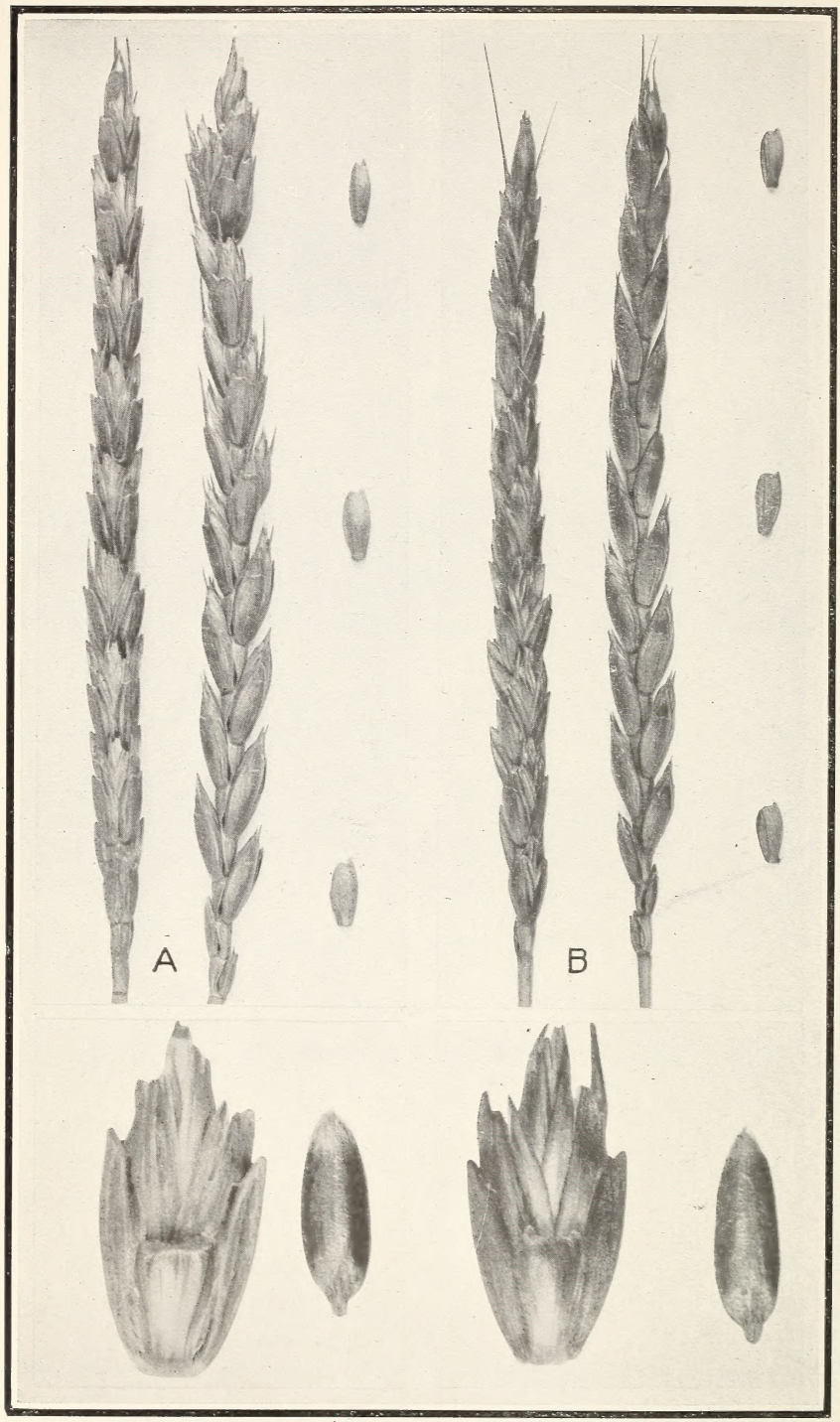
Einkorn is grown only sparingly in Europe and Asia and not at all in the United States, except experimentally.

Statistics on emmer and spelt are obtained in the United States and Europe only on both crops together. In Russia and the United States nearly all of the crop consists of emmer.

The countries leading in the production of emmer and spelt are Russia, Germany, and the United States. In some sections of Russia and Germany emmer occupies a larger acreage than wheat. In one government of Russia emmer is practically the only cereal grown. The acreage of emmer and spelt is decreasing in all countries, as they are being replaced by other cereal crops.



VERNAL (WHITE SPRING) EMMER (*A*); BLACK WINTER EMMER (*B*). SPIKES AND GLUMES NATURAL SIZE; SPIKELETS AND KERNELS MAGNIFIED 3 DIAMETERS.



WHITE SPRING SPELT (*A*); RED WINTER SPELT (*B*). SPIKES AND GLUMES NATURAL SIZE; SPIKELETS AND KERNELS MAGNIFIED 3 DIAMETERS.

COMMON EINKORN. SPIKE AND GLUMES NATURAL SIZE; SPIKELET AND KERNEL MAGNIFIED 3 DIAMETERS.

Statistics on emmer and spelt in the United States were not obtained previous to 1909. The acreage of emmer and spelt, according to the figures of the United States Census, decreased from 573,622 acres in 1909 to 166,829 acres in 1919. Owing to a difference in the method of obtaining these data in 1909 and 1919, however, it is possible that the actual decrease is slightly less. The States having the

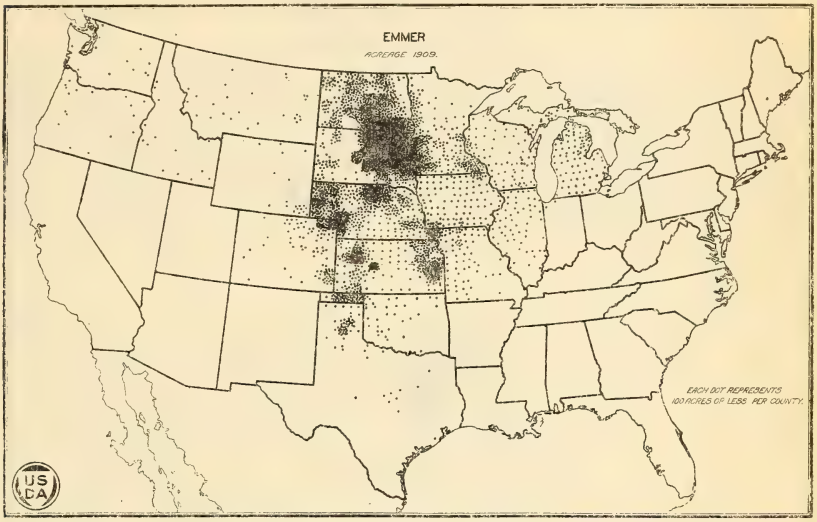


FIG. 1.—Outline map of the United States, showing the distribution of emmer in 1909 according to the United States census. Area, 573,622 acres. Each dot represents 100 acres or less per county.

largest areas of emmer and spelt, with the acreage grown in 1919, were South Dakota, 79,688 acres; North Dakota, 49,662 acres; Nebraska, 11,251 acres; Minnesota, 8,895 acres; and Colorado, 3,701 acres. The acreage and production of emmer and spelt in the 13 leading States in 1909 and 1919 are shown in Table 1.

TABLE 1.—*Acreage and production of emmer and spelt in the 13 States leading in the production of these grains and in the United States in 1909 and 1919*

[Data from the United States Census reports. Production calculated at 40 pounds per bushel.]

State.	Area grown (acres).		Production (bushels).	
	1909	1919	1909	1919
South Dakota	259,611	79,688	6,098,982	1,451,018
North Dakota	101,144	49,662	2,564,732	513,865
Nebraska	65,681	11,251	1,221,975	160,485
Minnesota	30,891	8,895	757,339	178,008
Colorado	15,523	3,701	324,713	52,832
Michigan	6,742	2,674	154,103	51,353
Wisconsin	6,090	2,290	166,301	50,495
Montana	1,308	2,125	39,830	13,838
Texas	4,624	1,453	44,316	43,040
Wyoming	1,521	942	35,677	6,452
Iowa	7,256	839	139,839	18,125
Kansas	49,969	291	785,362	4,574
Oklahoma	8,659	214	94,580	3,701
Other States	14,603	2,804	274,961	60,082
United States	573,622	166,829	12,702,710	2,607,868

The distribution of emmer in the United States in 1909 and 1919 is shown on the maps in Figures 1 and 2, respectively. It will be seen that the section of heaviest production is found in the northern Great Plains and the subhumid prairie section. Spelt is included with emmer in the census figures, but practically the entire production indicated is emmer. Emmer appears to be adapted to approximately the same conditions as durum wheat.

BUSHEL WEIGHT.

No standard bushel weights for emmer and spelt are established by Federal statutes in the United States, neither are such weights established for the Dominion of Canada. The weight used in computing acre yields of these crops in experiments of the Office of Cereal Investigations in recent years has been 32 pounds per bushel. This represents the approximate weight of grain as it comes from the

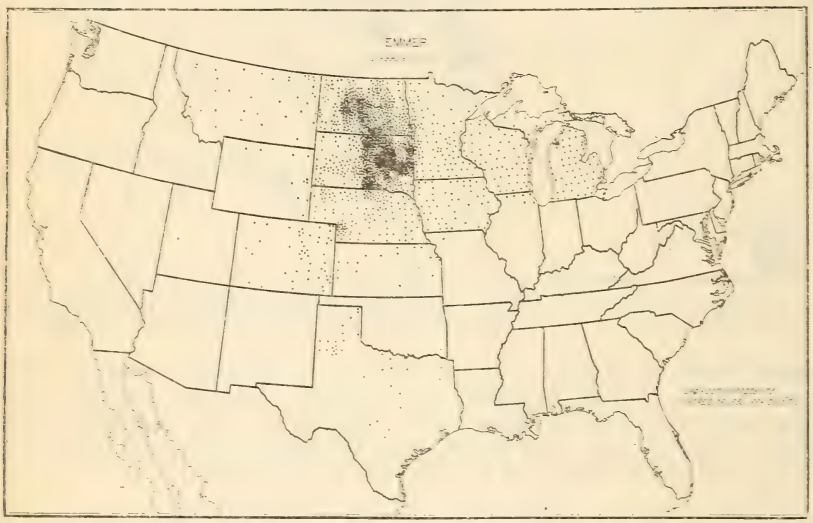


FIG. 2.—Outline map of the United States, showing the distribution of emmer in 1919 according to the United States census. Estimated area, 166,829 acres. Each dot represents 100 acres or less per county.

separator, most of it being still in the chaff. The United States Census Bureau uses a weight of 40 pounds per bushel in reporting statistics of emmer and spelt. The States of Illinois, Iowa, Kansas, Minnesota, North Dakota, Pennsylvania, and West Virginia have a legal weight of 40 pounds per bushel for spelt or speltz, while South Dakota recognizes 45 and Nebraska 48 pounds per bushel. Illinois, Iowa, and Kansas also specify 40 pounds and Nebraska 48 pounds per bushel for emmer.

The bushel weight used in determining the acre yield in the experiments here reported differed at nearly all stations and varied from 25 to 60 pounds per bushel. As there is so much confusion in these weights, the yields of emmer and spelt are best reported in pounds of grain as threshed per acre. This is the method used in this bulletin, in order to compare emmer and spelt with other crops.

Einkorn is more chaffy and usually is lighter in weight than either emmer or spelt. As it is not grown commercially in this country and is of no economic importance, no standard of weight is necessary.

COMPOSITION OF EMMER, SPELT, AND EINKORN.

In threshing, most of the kernels of emmer and spelt remain inclosed in the chaff or glumes. Varying proportions of free kernels are found mixed with the unbroken spikelets, depending upon the condition of the crop at threshing time and the operation of the threshing machine. The proportion of hulls or chaff to kernels, by weight, in a threshed sample depends also upon the plumpness of the kernels.

Saunders (*40*), in describing the varieties of emmer, spelt, and einkorn grown in experiments in Canada, reports the different varieties of emmer as having from 21 to 27 per cent of hull, spelt varieties from 27 to 38 per cent of hull, and einkorn 27 per cent of hull. In the same bulletin, Charon reports that two varieties of emmer grown at Ottawa, Canada, averaged 22.4 per cent of hull and two varieties of spelt averaged 29.4 per cent of hull. Zavitz (*71*) reported the average analyses of four varieties each of emmer and spelt, grown at Guelph, Ontario, during 12 seasons. Emmer showed 19.6 per cent and spring-sown spelt 28 per cent of hulls. Koernicke and Werner (*23*, vol. 2, p. 463), in Germany, report the average proportion of hulls in winter spelt as 25.5 per cent, in spring spelt as 23.8 per cent, in winter emmer as 23.6 per cent, and in spring emmer as 21.6 per cent. Determinations made in this country show emmer and spelt to consist usually of 20 to 30 per cent of hulls or chaff. As ordinarily threshed, emmer has somewhat less of hulls than spelt. In comparing these crops with wheat, about 22 per cent of emmer and 25 per cent of spelt should be regarded as hulls or chaff.

Chemical analyses by Shepperd (*47*, p. 12), Ladd (*48*, p. 436), Snyder (*51*), Hummel (*20*), Chamberlain (*9*), and others indicate that emmer has a composition similar to that of oats, being somewhat lower in fat and slightly higher in carbohydrates. Chamberlain (*9*, p. 43) reports the digestible nutrients of Black Winter emmer and oats, as shown in Table 2. In nutritive value, emmer appears to be slightly inferior to oats. Hulled emmer kernels have about the same composition as wheat kernels.

TABLE 2.—*Digestible nutrients in oats and in Black Winter emmer.*

[Computed in pounds per 100 pounds of dry matter.]

Cereal.	Protein.	Fat.	Crude fiber.	Carbohydrates.	Calories.
Emmer	9.96	1.36	4.98	52.06	74,356
Oats	10.73	3.59	3.17	51.04	77,209

Einkorn is considerably more chaffy than either emmer or spelt, but as it is not grown commercially the composition and uses are not here considered.

USES OF EMMER, SPELT, AND EINKORN.

The chief uses of these crops are as human food, as feed for livestock, and as parents in making hybrids for certain purposes.

USES AS HUMAN FOOD.

Emmer and spelt, although primarily feed grains, are used to a considerable extent as food in Europe, especially in Russia. Most of it is hulled and then ground into a meal which is cooked into porridge.

In Germany, emmer and spelt have been used for making flour (see Hauptfleisch, *17*). The threshed grain, consisting mostly of kernels inclosed in the chaff, which the Germans call "Veesen," is passed through a machine called a "Gerben," which removes the hulls and some of the embryos or germs. The kernels then are milled in much the same way as wheat. The flour obtained is of rather poor quality and if used for bread making usually is mixed with wheat flour.

Experiments in the United States by Sanderson (*38*), Stockham (*60*), LeClerc (*24*), and others have demonstrated that flour from emmer and spelt can be made into bread, but the bread is dark colored and about equal in quality to that made from low-grade or "Red Dog" wheat flour. Some emmer is being milled into an uncooked breakfast food in this country.

A food called grünkorn, the groats or prepared grain from unripe spelt (*Triticum spelta*), is liked especially in western and southwestern Germany (*1*). To prepare this, spelt is harvested when the kernels begin to lose their milky nature and to become mealy and reddish yellow. Then the spelt is dried in an oven, threshed, and the kernels shelled in the shelling machinery of the mill. Since the yield of grünkorn is much less than that of ripened grain (about one-tenth) the price is high. The manufacture of grünkorn is carried on especially in Scheffbergerthal, in the vicinity of Mosbach on Neckar. From grünkorn, soups, porridge, etc., are prepared. Grünkorn is highly regarded in south Germany along the Rhine for making soup. The kernels are washed thoroughly by stirring in lukewarm water and the water drained away, then cooked with water and butter until quite soft, rubbed through a sieve, cooked again with meat broth, and thickened with yolk of egg. Often the kernels first are crushed or ground into meal.

USES AS FEED FOR LIVESTOCK.

Nearly all of the emmer and spelt grown in the United States is fed to livestock. Much of it is ground before being fed. Hummel (*20*) reports a considerable increase in digestibility after grinding whole emmer. As previously stated, emmer is about equal to oats in composition and corresponds rather closely with that grain in feeding value. Because of its bulk, emmer gives better results when mixed with other grains or concentrates. Mixed with linseed meal and fed with corn silage, it proved to be equal to ground corn for fattening steers in South Dakota (*67*). A mixture of equal quantities of emmer meal and corn meal fed to fattening pigs was nearly equal to corn meal alone (*52*).

For dairy cows getting brome-grass hay and corn silage for roughage, about 13 per cent more emmer than corn or barley meal was required to produce equal quantities of butterfat. It required 125 pounds of emmer to replace 100 pounds of corn when fed to steers receiving prairie hay as roughage (*69*). Emmer produces a hard fat and meat of as good quality as corn when fed to baby beeves (*68*). For lambs, the value of emmer appears to be about 80 per cent of that of corn (*19*, p. 530). When fed alone to pigs, 31 per cent more emmer meal than corn meal and 5 per cent more emmer meal than barley meal were required to produce 100 pounds of gain (*52*).

USES AS PARENTS IN HYBRIDIZATION.

Because of the persistent chaff of emmer and spelt, it has been suggested that these grains be used to cross with wheats to prevent shattering. The fragile rachis of emmer and spelt is fully as objectionable as the fragile glume and kernel attachment which permits shattering of the common wheats. In order to avoid losses from the breaking up of the heads, emmer must be harvested as soon as it is ripe or even before. Because of this, and for reasons mentioned later, emmer and spelt are less desirable for hybridization than are many of the nonshattering varieties of wheat. Because of the rust resistance of some varieties of emmer, they have been used in crossing with wheats to obtain strains resistant to rust. Hayes, Parker, and Kurtzweil (*18*) have shown that a high percentage of sterility results from these crosses of common wheat and emmer and also that the rust-resistant factors are linked with the emmer characters. Fertile hybrids resulting from crosses of the common and club wheats with either emmer or spelt show a great diversity of plant forms, with very few pure types of wheat free from objectionable emmer and spelt characters in both spikes and kernels.

Sax (*42*) and other investigators have noted that hybrids between members of the three wheat groups are more or less sterile in the F_1 and later generations.

Leighty and Boshnakian (*25*) have shown that spelt and common wheat are differentiated by a number of linked specific characters, which are present in one species and absent in the other. These characters, so far as observed, are not inherited independently, but are transmitted as a group. In crosses between spelt and common wheat the F_1 hybrid shows a dominance of the spelt, but this character appears in a somewhat diluted form. In the second generation all classes of spelt inheritance are obtained. Evidence is also presented by them that speltlike forms are sometimes produced by crossing certain wheats.

Einkorn is of practically no value in wheat breeding, as crosses between einkorn and wheat are very difficult to make and are nearly always sterile.

VARIETIES.

More than 20 distinct groups of emmer, spelt, and einkorn are known, only part of which have been grown experimentally in the United States and Canada. As previously stated, spelt is not grown commercially in this country, except to a very limited extent, and einkorn not at all. Nearly all of the emmer grown in the United States is of one variety, so that descriptions of varieties are chiefly of interest to experimenters.

VARIETIES OF EMMER.

Three distinct varieties of emmer are known to be commercially grown in the United States. Two of these are bearded white-glumed spring varieties, and the other is a bearded black-glumed winter variety. A few additional varieties here described have been grown in experimental plats. Many additional varieties and strains of emmer have been grown in nursery experiments, but the yields or other data from them are not here given. Four varieties of emmer grown in plat experiments in Canada have been grown only

in nursery experiments in the United States. Brief descriptions of these, as reported by Saunders (*39*), are here presented.

BLACK WINTER.

Black Winter emmer has awned inclined spikes and pubescent, bluish black glumes (Pl. I, *B*). The spikes are narrow from the face view of the spikelets, but wide in the other dimensions and usually 3 to 4 inches long. The leaves are very pubescent. The plants are tall and late and the stems white or yellow. The awns are easily broken off at maturity, so that some spikes appear to be awnless. The rachis is fragile at maturity, necessitating care in harvesting to avoid losses from breaking of the spikes. Under very favorable conditions of soil moisture and fertility the spikes tend to branch, forming composite spikes. Under unfavorable conditions the black color of the glumes does not develop fully, and they become a dark brown or gray.

Black Winter is quite susceptible to injury from stem rust. It is hardier than winter barley or winter oats but not as hardy as many varieties of winter wheat and frequently is partly or entirely winterkilled when grown in the Great Plains and Intermountain States.

Black Winter (or Black Velvet) has long been known in Europe. It was advertised for many years by Vilmorin-Andrieux & Co., seedsmen, of Paris, France. About 79 pounds of the Black Winter emmer were obtained from this firm by the United States Department of Agriculture in 1904. After having been grown and increased for a few years it was distributed to farmers and experimenters. Prof. B. C. Buffum, of Worland, Wyo., obtained about 2 quarts of seed of Black Winter emmer from the department and sowed it in the fall of 1907. Only 72 plants survived the winter, but seed from 12 of these plants was increased and later distributed as "Buffum's Improved Black Winter" emmer. It is identical, however, with the original importation in all characters observed, including hardiness. Most of the Black Winter emmer which has been sown in the Great Plains area during recent years has been winterkilled.

WHITE WINTER.

White Winter emmer has slender awned spikes and glabrous white glumes. It matures at about the same time as Black Winter, but the plants are somewhat shorter. This variety (C. I. No. 3628; S. P. I. No. 34369)[2] was introduced by the United States Department of Agriculture in 1912. It was obtained from Vilmorin-Andrieux & Co., seedsmen, of Paris.

BROWN WINTER.

A variety of emmer having awned spikes and glabrous brown glumes has been developed in experiments at Moro, Oreg. This variety or strain was selected from a plat of Black Winter emmer (C. I. No. 2483) and apparently was the result of natural crossing. Another selection from the Black Winter variety had glabrous white glumes, but it was not grown in plat experiments. Brown Winter emmer has not been distributed for commercial growing.

[2] C. I. No. refers to accession numbers of the Office of Cereal Investigations; S. P. I. No. refers to accession numbers of the Office of Foreign Seed and Plant Introduction (*64*).

VERNAL (WHITE SPRING).

Vernal (White Spring), or Common (known also as Ufa and Yaroslav), emmer has awned spikes, glabrous white glumes, and purple stems. The heads usually are 2 to 2½ inches long, rather slender, and nodding (Pl. I, *A*). The rachis becomes disjointed easily at maturity. The plants are of medium height, being shorter than most varieties of wheat. They mature at about the same time as midseason varieties of oats. Vernal is very resistant to several forms of stem rust and leaf rust, and injury from rust seldom occurs under field conditions.

The Vernal (White Spring) variety probably comprises at least 95 per cent of the emmer and "spelt" grown in the United States and Canada. It is the variety listed in nearly all seed catalogues as "speltz," although this name is sometimes applied to seed of the true spelt. Experiment-station publications usually refer to this variety under the descriptive names "White Spring" emmer or "Common" emmer. To avoid confusion with White Spring spelt, it has recently been named "Vernal" (*12*). Vernal emmer was introduced into the United States by German-Russian immigrants who settled in the Dakotas. It is said to have been introduced into North Dakota by Russian settlers living in McIntosh County (*49*). More recent introductions from Russia were made by the United States Department of Agriculture in 1898 and 1899. Samples received were named Ufa and Yaroslav, because of their having been obtained in the Ufa and Yaroslav Governments of Russia, but they have proved to be identical with the Vernal (White Spring) variety.

KHAPLI.

This variety differs from Vernal (White Spring) principally in being earlier and in having wider spikes and shorter stems, which are white or yellow rather than purple. The spikelets and kernels of Khapli also are larger. Khapli is nearly immune to all forms of rust commonly occurring in the United States. In general appearance it resembles the wild emmer (*Triticum dicoccum dicoccoides*) more closely than do other emmer varieties.

Khapli was first introduced into this country by the United States Department of Agriculture from Hoshangabad, Central Provinces, India, in 1908. In 1914, and again in 1915, additional introductions of this emmer, under the name Kathiawar, were obtained by the department from the district of Kathiawar, north of Bombay, in India. Reports that it grows wild in Kathiawar have not been confirmed.

After being grown in cooperative experiments at the Highmore (S. Dak.) substation, Khapli was distributed to farmers in South Dakota for commercial growing in 1917. Some acreage of this variety may still be grown in that State.

OTHER SPRING VARIETIES.

An unnamed white emmer, similar to Vernal except in having longer spikes and in being several days later in maturing, formerly was grown in plat experiments in Canada, but only in nursery experiments in the United States.

According to Saunders (39), a variety with long, slender spikes and white glumes was grown in plat experiments in Canada under the name of "Long" emmer. It matured about two weeks later than Vernal, but apparently is quite similar to the White Winter (C. I. No. 3628), obtained from France by the department.

Another variety, grown in limited experiments, differs from the others described here in having spikes somewhat clavate or clubbed at the tips. It was called Thick emmer by Saunders (39), who states that it ripens approximately with Vernal.

Red is a spring variety with long, slender spikes and red or brown glumes, which matures several days later than Vernal. It has been grown in plat experiments in Canada, but only in nursery rows in the United States.

VARIETIES OF SPELT.

Only five varieties of spelt have been grown in plat experiments in the United States within recent years. Several others have been grown in nursery experiments for observation, but they were not increased. It is believed that only two varieties are grown commercially in the United States, and these are of very minor importance.

ALSTROUM.

Alstroum has long slender, lax, nodding, awnless spikes, and glabrous white glumes. It differs from White Spring, described later, principally in being a winter variety. The spikes are more nodding than those of the White Spring variety, and the stems show a trace of purple color. The spikes are almost free from the short apical or tip awns. Although a winter variety, Alstroum will mature seed even when sown in the spring. Alstroum was obtained by the department from the Washington Agricultural Experiment Station in 1901, but the previous history of the variety is not known. A selection has been grown at Arlington Experiment Farm, Rosslyn, Va., since 1911.

Considerable quantities of Alstroum have been distributed to farmers during the past few years by the department from the Arlington Experiment Farm. It is now grown on a small acreage in Virginia, and commercial distribution of the seed is being made.

RED WINTER.

Red Winter, or Red, has long, slender, lax, erect, awnless spikes, and glabrous brown glumes. Although awnless, the spikes bear a few apical or tip awns (Pl. II, *B*). In height, maturity, and straw color Red Winter is very similar to Alstroum. Like the latter variety it can be matured from spring sowing. This variety appears to be more hardy than any variety of winter emmer.

Doubtless several lots of Red Winter have been introduced from Europe. The sample from which came the seed for most of the experiments here reported was obtained from the Washington Agricultural Experiment Station in 1901. Its previous history has not been determined. Seed of this variety under the name "Brown Winter" was introduced from Switzerland about 1913 by Paul Scheddiger, of Spearfish, S. Dak., and was distributed by him in 1915. It was sown on a considerable acreage in the Black Hills district of South Dakota and Wyoming, but was nearly all winterkilled during

the rather severe winters of 1915–16 and 1916–17. Very little if any of this spelt is now grown. Red Winter has been distributed by the department and by several experiment stations, but it is not extensively grown.

Red Winter is believed to be identical or nearly identical with the Red spelt grown from spring sowing in experiments in Canada.

WHITE BEARDED.

This variety (C. I. No. 1774) differs from the varieties previously described in having awned spikes and rather yellowish glumes. The spikes are long, slender, and lax, and the glumes are glabrous and have a pointed shoulder. It is a winter variety but will mature seed from spring sowing. This spelt was obtained from the Washington Agricultural Experiment Station in 1901, along with the Alstroum and Red Winter varieties. It is identical with a lot, C. I. No. 1724, obtained from Serbia through the Paris Exposition in 1900. A similar variety of spelt was grown at College Park, Md., under the name "White Bearded." This was obtained by the department from Haage & Schmidt, seedsmen, of Erfurt, Germany, in 1904. None of these is known to be grown commercially in the United States. A White Bearded spelt apparently identical with the one here described was grown also in experiments in Canada.

BLACK BEARDED.

The Black Bearded spelt is very similar to the White Bearded variety except in having black glumes and awns. The color varies in intensity from brown to black, according to environment. This variety has been grown in plat experiments only in Canada.

WHITE SPRING.

White Spring has long, slender, lax, erect, awnless spikes and glabrous white glumes (Pl. II, *A*). The plants are of medium height and are late in maturing. The stems are white or yellow. This variety probably has been introduced into the United States at several different times. White Spring, which has been grown in the experiments reported later, was obtained in 1904 from J. M. Thorburn & Co., seedsmen, of New York City. The original source of the seed is not known. White Spring is not known to be grown commercially in the United States.

VARIETIES OF EINKORN.

Two varieties of einkorn have been grown in experiments in the United States and Canada. The most important one is the Common or single einkorn.

COMMON.

Common einkorn contains only one kernel in each spikelet (Pl. III). It usually has been grown from fall sowing, but was sown in the spring in experiments in the Dakotas and Canada. When sown in the spring it makes a slow growth, but eventually the spikes are exserted and the seed matures late in the season. The samples of this variety which were grown in the experiments were from seed originally obtained in Germany by the United States Department of Agriculture.

DOUBLE.

The Double, or Spring, variety contains two kernels in each spikelet. It has been grown only in limited experiments. The lot of seed from which this variety was grown in the United States in the experiments reported here was obtained from the Washington Agricultural Experiment Station in 1901.

VARIETAL EXPERIMENTS.

This bulletin contains nearly all the results of important experiments with emmer and spelt which have been conducted in the United States and Canada. The early experiments were begun about 1898, when these crops, especially emmer, began to assume importance on farms. Some experiments have continued until the present, but many of them were discontinued after a few years of unfavorable returns.

SOURCES OF DATA.

Most of the results with emmer, spelt, and einkorn presented herein have been obtained in experiments conducted in the various States by the Office of Cereal Investigations, either cooperatively with the State experiment station or with some other agency. At the remaining stations the data have been obtained independently by the State or Province. The source of the data is stated in connection with each station. Many of the data presented here have been published wholly or in part in bulletins of the United States Department of Agriculture or in bulletins and annual reports of the State experiment stations and of the Canadian experimental farms. A considerable portion of the data, however, has been taken from the unpublished annual reports of the field stations conducted by the Office of Cereal Investigations of the department.[3]

The experimental conditions, such as crop sequence, size of plat, width of alleys, number of replications, etc., vary somewhat at different stations and at the same station in different years. The results obtained at one station in any one year, therefore, are not necessarily comparable with those obtained at any other station or at the same station during other years. In most cases, however, they are fairly comparable, and some of the stations have grown these crops under nearly identical conditions for several consecutive years.

In order to determine the value of emmer and spelt for any section it is necessary to compare the yields with those of the other small-grain crops with which they must compete, viz, barley, oats, wheat, and rye. The kernels of the two latter crops are completely sepa-

[3] The men who have had charge of the cereal experiments conducted at the various stations, either independently or cooperatively by the Office of Cereal Investigations, during the period in which these data were obtained, are as follows: *California.*—Chico, H. F. Blanchard, E. L. Adams; Modesto, H. F. Blanchard. *Colorado.*—Akron, W. G. Shelley, Clyde McKee, C. H. Clark, G. A. McMurdo, and F. A. Coffman. *Georgia.*—Athens, R. R. Childs. *Idaho.*—Aberdeen, L. C. Aicher. *Kansas.*—Hays, F. A. Kiene, jr.; McPherson, V. L. Cory. *Maryland.*—College Park, N. Schmitz. *North Dakota.*—Dickinson, L. R. Waldron, C. H. Clark, J. A. Clark, and R. W. Smith; Edgeley, O. A. Thompson; Fargo, J. H. Shepperd and O. O. Churchill; Williston, F. R. Babcock. *Oregon.*—Burns, L. R. Breithaupt; Moro, H. J. C. Umberger and D. E. Stephens. *South Dakota.*—Brookings, J. S. Cole, Clifford Willis, and M. J. Champlin; Cottonwood, M. J. Champlin; Eureka, M. J. Champlin; Highmore, M. J. Champlin, J. D. Morrison, and E. S. McFadden; Newell, S. C. Salmon, E. M. Johnston, J. H. Martin, and A. D. Ellison. *Texas.*—Amarillo, A. H. Leidigh and J. F. Ross; Channing, A. H. Leidigh. *Utah.*—Nephi, F. D. Farrell, P. V. Cardon, A. D. Ellison, J. W. Jones, and A. F. Bracken. *Virginia.*—Arlington Experiment Farm, T. R. Stanton, A. D. Ellison, H. P. Ames, and J. W. Taylor. *Washington.*—Lind, M. A. McCall. *Wyoming.*—Archer, J. W. Jones, V. H. Florell, and A. L. Nelson. Special acknowledgment is due A. C. Arny, associate agronomist at University Farm, St. Paul, Minn., and T. E. Stoa, assistant agronomist of the North Dakota Agricultural Experiment Station, Agricultural College, N. Dak., for furnishing unpublished yield data to the writers. Professor Arny supplied the data from University Farm, St. Paul, Minn., and the 1920 and 1921 yields from the Crookston and Grand Rapids, Minn., substations. Mr. Stoa furnished the yield data obtained at Fargo, N. Dak., since 1906.

rated from the glumes (chaff) in threshing, so that the weights of threshed grain are not directly comparable with those of emmer and spelt. Most of the wheat and rye also is sold for milling purposes, while emmer and spelt are used almost exclusively for feeding livestock. Row crops, such as corn and grain sorghum, although grown as feed crops, do not compete directly with the small-grain crops which are sown at different seasons and in different sequences in the rotation.

Barley and oats are grown chiefly for feeding purposes, and as already pointed out the kernels remain in the glumes after threshing, so that they are directly comparable in yield with emmer and spelt. The yields of emmer and spelt given here are compared directly with the yields of the leading variety of barley and oats at each station. The varieties selected, in nearly all cases, were the ones having the highest average yields in the years during which emmer and spelt were grown and not the highest yielding varieties of each year. The yields of the crops are computed in pounds per acre, in order that they may be compared directly at all stations.

Although emmer, spelt, einkorn, barley, and oats all have the glumes adhering after threshing, the net weights are not strictly comparable because of the different proportions of hull or glumes. In general, emmer may be said to consist of about 22 per cent of hull, spelt 25 per cent, barley 15 per cent, and oats 30 per cent. These differences are not considered in these computations, as the crops also vary somewhat in feeding value.

In some sections wheat is considerably more productive than barley and oats, as well as emmer and spelt. In these sections wheat could be compared with emmer and spelt by adding 25 per cent to the yields of the wheat. This has not been done in the tables presented here, but at a few stations the comparative yields of wheat are mentioned.

GEOGRAPHIC SCOPE.

The results of experiments with emmer and spelt reported here were obtained at 52 experiment stations in 19 States in the United States and in 6 Provinces in Canada. The location of these stations is shown in Figure 3. The area covered extends from the Atlantic to the Pacific coast and from Georgia, Texas, and Arizona in the south to Canada in the north.

The adaptation and value of emmer and spelt vary with environment. There is a wide variation of soil and climate within the territory covered by the experiments. For convenience in presenting and interpreting results, the territory under discussion is separated into four divisions, according to environmental conditions. These are called (1) the South Atlantic (humid) area, (2) the Mississippi and St. Lawrence Valleys (subhumid) area, (3) the Great Plains (semiarid) area, and (4) the Western Basin and Coast area.

The locations of the stations, together with their altitude above sea level, are shown in Table 3. The normal or average rainfall in inches, with the number of years on which such average is based, also is given. The United States Weather Bureau establishes normals for its independent stations on 33-year records. At all other points the rainfall recorded is the average for the years during which observations have been made. Finally, the table shows the general soil type on which each station is located.

TABLE 3.—*Altitude, normal or average precipitation, and soil type at 52 experiment stations at which experiments with emmer and spelt have been conducted.*

Area and station.	Altitude.	Precipitation.		Type of soil.
		Normal or average.	Length of record.	
South Atlantic (humid) area:	*Feet.*	*Inches.*	*Years.*	
Athens, Ga.	694	49.88	44	Cecil clay loam and Cecil sandy loam.
Rosslyn, Va.	50	41.10	10	Clay.
College Park, Md.[1]				Brown sandy loam.
Mississippi and St. Lawrence Valleys (subhumid) area:				
Denton, Tex.		34.45	9	
McPherson, Kans.	1,495	32.32	20	Deep sandy loam.
Manhattan, Kans.	1,014	32.59	61	Dark-brown silt loam.
La Fayette, Ind.	617	38.29	29	
Madison, Wis.	974	31.25	51	
St. Paul, Minn.	848	27.80	38	Light clay loam.
Morris, Minn.	1,170	23.51	23	
Grand Rapids, Minn.		[2] 28.05	22	
Crookston, Minn.	863	23.01	20	Heavy clay loam.
Brookings, S. Dak.	1,636	19.99	30	Glacial sandy loam.
Fargo, N. Dak.	935	[3] 24.92	33	Heavy black clay loam.
Guelph, Ontario.	1,050	27.05	33	Clay loam.
Ottawa, Ontario.	294	32.60		Do.
Nappan, Nova Scotia.		35.81	7	Do.
Great Plains (semiarid) area:				
Amarillo, Tex.	3,676	20.81	28	Chocolate clay loam.
Channing, Tex.	3,900	21.12	3	Sandy clay loam.
Hays, Kans.	2,000	23.16	53	Silty clay loam.
Akron, Colo.	4,560	18.86	17	Sandy loam.
North Platte, Nebr.	3,000	18.86	33	Loess.
Archer, Wyo.	6,027	[4] 14.23	33	Medium sandy loam with some gravel.
Jireh, Wyo.		[5] 14.03	21	
Sheridan, Wyo.	3,800	14.72	23	Dark clay loam.
Highmore, S. Dak.	1,890	16.75	26	Glacial clay loam.
Eureka, S. Dak.	1,884	16.43	7	Glacial sandy loam, stony portion of old moraine.
Cottonwood, S. Dak.	2,414	15.54	7	Clay (gumbo), shale subsoil.
Newell, S. Dak.	2,900	14.31	12	Do.
Hettinger, N. Dak.	2,253	13.78	28	Morton clay loam.
Dickinson, N. Dak.	2,453	15.17	30	Sandy loam to clay loam.
Williston, N. Dak.	1,875	14.90	33	Fine sandy loam.
Edgeley, N. Dak.	1,468	[6] 20.25	17	Light sandy loam, shale subsoil.
Langdon, N. Dak.	1,615	[7] 16.83	11	Black clay loam.
Brandon, Manitoba.	1,176	12.95	9	Sandy loam.
Indian Head, Saskatchewan	1,924	19.44	10	Light sandy loam to heavy loam.
Rosthern, Saskatchewan.	1,657	15.01	7	
Lethbridge, Alberta.	2,961	15.45	10	Dark loam.
Lacombe, Alberta.	2,783	17.62	10	Black clay loam.
Western Basin and Coast area:				
Phoenix, Ariz.	1,108	7.39	38	
Cochise, Ariz.	4,219	11.41	25	Red loam.
Prescott, Ariz.	5,008	17.40	18	Loam.
Snowflake Ariz.	5,600	13.24	5	Sandy loam.
Modesto, Calif.	90	10.52	49	
Paso Robles, Calif.	800	16.04	23	
Chico, Calif.	189	23.59	50	Do.
Nephi, Utah.	6,000	13.27	22	Clay loam.
Aberdeen, Idaho.	4,400	9.05	9	Sandy clay loam.
Burns, Oreg.	4,100	7.49	6	Silt loam to fine sandy loam.
Moro, Oreg.	1,800	11.53	17	Silt loam.
Lind, Wash.	1,630	7.25	3	Fine sandy silt loam.
Agassiz, British Columbia.	52	63.78		Sandy loam.

[1] Climate very similar to Rosslyn, Va., 10 miles southwest.
[2] Observations made at Pokegama Falls, Minn., 7 miles northwest.
[3] Observations made at Moorhead, Minn., opposite Fargo.
[4] Observations made at Cheyenne, Wyo., 9 miles west.
[5] Observations made at Lusk, Wyo., 14 miles east.
[6] Observations made at Berlin, N. Dak., 12 miles east.
[7] Observations made at Woodbridge, N. Dak., 24 miles northwest.

RESULTS IN THE SOUTH ATLANTIC AREA.

The eastern or humid area comprises the States east of the Mississippi Valley and south of the St. Lawrence Valley. In this area rainfall usually is ample for maximum yields of small grains and soil fertility is the chief limiting factor. Winter wheat is the leading small grain in this area.

From Virginia southward winter varieties of barley and oats are grown, but north of Virginia spring barley and oats are grown.

FIG. 3.—Outline map of the United States and part of Canada, showing division into climatic-topographic areas and the location of the 52 agricultural experiment stations where the results with emmer, spelt, and einkorn reported herein were obtained.

Only a few experiments with emmer and spelt have been conducted in the eastern or humid area of the United States. Preliminary trials with these crops at several experiment stations during one or two seasons usually were not promising, and the experiments were discontinued. Emmer and spelt have produced rather poor yields in the North Atlantic States. In other Eastern States, however, spelt has given good results. Results obtained at three stations in the eastern or humid area are shown.

RESULTS AT ATHENS, GA.

Two varieties of winter emmer and one variety of winter spelt were grown at Athens, Ga., during the five years from 1915 to 1919,

inclusive. These experiments were conducted cooperatively by the State College of Agriculture of the University of Georgia and the Office of Cereal Investigations. The results are shown in Table 4. Serbia winter spelt at this station yielded considerably more than either variety of emmer, and the average yield was only slightly less than that of Appler oats. Tennessee Winter barley was the most productive crop at Athens, yielding an average of 2,188 pounds per acre. This was almost double the yield of spelt and nearly three times the yield of Black Winter emmer.

TABLE 4.— *Yields of two varieties of emmer and one variety each of spelt, barley, and oats grown at Athens, Ga., in the 5-year period from 1915 to 1919, inclusive.*

[Data obtained in cooperation with the State College of Agriculture of the University of Georgia.]

Crop and variety.	C. I. No.	Yields per acre (pounds).					
		1915	1916	1917	1918	1919	Average.
Emmer:							
Black Winter	2337	975	275	572	1,065	985	774
White Winter	3628	938	301	0	.....	.....	.....
Spelt:							
White Bearded (Serbia)	1724	1,625	576	723	1,402	1,215	1,108
Barley:							
Tennessee Winter	257	2,102	2,952	413	3,400	2,074	2,188
Oats:							
Appler	1815	2,100	2,026	0	224	1,575	1,185

RESULTS AT ARLINGTON EXPERIMENT FARM, ROSSLYN, VA.

Several varieties of both winter emmer and spelt have been grown since 1910 at Arlington Experiment Farm, near Rosslyn, Va., opposite Washington, D. C. These experiments are conducted independently by the Office of Cereal Investigations. The results have been published in part by Stanton (*55*). The yields obtained during the past 12 years are shown in Table 5.

The average acre yield of Black Winter emmer is only 641 pounds, indicating that it is not adapted to the conditions at Arlington. The yields of spelt, however, are very satisfactory. Alstroum spelt yielded an average of 2,180 pounds per acre, while a selection from this variety yielded slightly more. During the same period Tennessee Winter barley averaged 1,434 pounds and Winter Turf oats 1,586 pounds per acre. Partial winterkilling of emmer, barley, and oats sometimes occurs, while spelt is not injured. The greater hardiness of winter spelt is partly responsible for the higher yields. It is also better adapted to the general climatic conditions of this section than emmer. The difference in adaptation is comparable to that existing between the soft red winter wheats and the hard red winter wheats (Crimean group), the latter not being adapted to this section. Spring grains produce comparatively low yields at Arlington, so winter spelt is the most productive of the small grains used for feed. This crop should be more extensively grown in those portions of Maryland and Virginia having conditions similar to those at Washington, D. C.

TABLE 5.—*Yields of three varieties of emmer, four varieties of spelt, and one variety each of barley and oats, at Arlington Experiment Farm, Rosslyn, Va., in the 12-year period from 1910 to 1921, inclusive.*

Crop and variety.	C. I. No.	Yields per acre (pounds).												
		1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	Average, 1911 to 1921.
Emmer:														
Black Winter	2337	1,029	351	921	615	435	611	960	1,510	829	346	157	320	641
Black Winter selection	2337-1	1,101	597	1,041	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
White Winter	3628	.....	.....	.....	.....	.....	202	464	541	435	154	.....	.....	.....
Spelt:														
Alstroum	1773	2,640	1,521	2,346	1,539	3,066	2,448	1,872	3,206	2,940	1,267	2,333	1,446	2,180
Alstroum selection	3264	.....	1,440	2,691	1,479	3,213	2,208	2,080	2,941	2,807	1,568	2,266	1,603	2,209
Red Winter	1772	2,559	1,350	2,397	1,620	2,913	2,415	1,740	3,081	2,521	1,225	2,540	.....	.....
White Bearded (Serbia)	1724	1,710	1,221	2,241	1,449	2,616	2,086	2,192	2,740	2,044	1,420	2,205	2,118	2,030
Barley:														
Tennessee Winter	257	1,123	720	1,695	1,042	1,473	1,684	1,925	2,012	1,613	1,492	1,023	1,098	1,434
Oats:														
Winter Turf	431	.....	941	810	1,280	1,982	2,208	1,651	1,892	1,453	2,186	685	2,353	1,586

RESULTS AT COLLEGE PARK, MD.

Emmer and spelt were grown in experiments at the Maryland Agricultural Experiment Station, College Park, Md., during the 8-year period from 1909 to 1916, inclusive. From 1909 to 1914 these experiments were conducted cooperatively by the Maryland station and the Office of Cereal Investigations. The results obtained have been published by Stanton (*55*). The yields in 1915 and 1916, obtained independently by the State, were reported by Schmitz (*43*). College Park, Md., is only about 10 miles from Arlington Experiment Farm, in Virginia, so the results (Table 6) might be expected to be rather similar.

TABLE 6.—*Yields of three varieties of emmer, five varieties of spelt, and one variety each of barley and oats, grown at College Park, Md., in the 8-year period from 1909 to 1916, inclusive.*

[Data obtained in cooperation with the Maryland Agricultural Experiment Station.]

Crop and variety.	C. I. No.	Yields per acre (pounds).									
		1909	1910	1911	1912	1913	1914	1915	1916	Average. 1909 and 1910.	Average. 1909 to 1914.
Emmer:											
Black Winter	2337	633	1,074	1,356	960	1,104	1,455	651	.....	854	1,097
Black Winter selection	2337-1	645	1,005	1,413	1,101	1,023	567	.....	.....	825	959
White	2101	375	924	.....	.....	.....	.....	.....	.....	650	.....
Spelt:											
Alstroum	1773	1,575	1,779	2,109	2,091	1,629	2,199	.....	.....	1,677	1,897
Red Winter	1772	1,293	1,857	1,989	2,160	1,983	2,091	1,011	1,104	1,575	1,896
White Bearded	1724	1,635	1,611	.....	.....	.....	.....	.....	.....	1,623	.....
Do	1774	681	1,446	.....	.....	.....	.....	.....	.....	1,064	.....
Do	2481	1,578	1,500	.....	.....	.....	.....	.....	.....	1,539	.....
Barley:											
Tennessee Winter	257	1,430	994	1,575	2,046	1,527	1,718	758	.....	1,212	1,548
Oats:											
Winter Turf	180	1,072	1,495	1,674	2,120	1,568	1,539	.....	.....	1,283	1,577

Alstroum spelt produced an average yield of 1,897 pounds per acre and Red Winter yielded practically the same. Tennessee Winter barley gave an average yield of 1,548 pounds and Winter Turf oats 1,577 pounds per acre. Black Winter emmer yielded considerably less than these crops. Here, as at Arlington, winter spelt is much more productive than either barley or oats. At both stations, however, the best varieties of winter wheat yielded more than winter spelt when allowance is made for 25 per cent of hulls in the spelt.

RESULTS IN THE MISSISSIPPI AND ST. LAWRENCE VALLEYS.

The subhumid area extends from the Great Plains to the eastern border of the Mississippi Valley and from the head of the Mississippi River east to the Atlantic coast. The area includes the region designated as the Corn Belt, the prairie sections north and south of the Corn Belt region, the Great Lakes region, and the St. Lawrence Valley. The precipitation in most of the area ranges from 20 to 30 inches, but reaches 40 inches in the extreme eastern and southern portions.

Winter wheat is the leading small grain in the southern half of the area and spring wheat in the northern portion. Oats is the leading small grain for feed in the Corn Belt and is important in the northern portion of the prairie area. Barley is of importance in this area only in Minnesota, in Wisconsin, in the eastern portions of the Dakotas, and in Canada.

Only a few experiments with emmer and spelt have been reported in the prairie or subhumid area. Corn is the principal feed grain in all except the northern portion, so that barley and oats are grown largely because they fit into the rotation scheme. A few preliminary trials in the Corn Belt States indicated the unsuitability of emmer in comparison with oats, so that long-continued data are not available. In the northern portion of the prairie area the results with emmer have been more favorable, and more experiments with that crop have been reported. The results obtained in the subhumid area are here given.

RESULTS AT DENTON, TEX.

Emmer and spelt were grown for three years at Texas substation No. 6, at Denton. The yields, as reported by Cory (*15*) in Bulletin No. 199 of the Texas Agricultural Experiment Station, are shown in Table 7. Black Winter emmer gave an average yield of 888 pounds per acre, Red Winter spelt 1,080 pounds, Tennessee Winter barley 1,538 pounds, and Red Rustproof oats 1,354 pounds per acre. Emmer and spelt are not as productive as barley and oats in this section of Texas.

TABLE 7.—*Yields of one variety each of emmer, spelt, barley, and oats grown at Denton, Tex., in 1912, 1913, and 1914.*

[Data compiled from Texas Agricultural Experiment Station Bulletin 199(*15*).]

Crop and variety.	Yields per acre (pounds).			
	1912	1913	1914	Average.
Emmer: Black Winter	1,220	1,086	358	888
Spelt: Red Winter	1,605	1,383	252	1,080
Barley: Tennessee Winter	2,170	1,680	763	1,538
Oats: Red Rustproof	1,700	1,760	602	1,354

RESULTS AT McPHERSON, KANS.

Experiments with emmer, spelt, and einkorn were in progress at McPherson, Kans., from 1905 to 1909. The data, obtained cooperatively by the Office of Cereal Investigations and the Kansas Agricultural Experiment Station, were published in 1912 by Cory (*14*). The yields are given in Table 8.

Spring emmer and einkorn produced low yields. Black Winter emmer and Red Winter spelt yielded more than winter barley, but less than spring barley and spring oats. Winter wheat is the leading small-grain crop at McPherson, and its yields, which are not shown, are higher than the yields of any of the grains which are given in Table 8.

TABLE 8.— *Yields of three varieties of emmer, one of spelt, four of einkorn, two of barley, and one of oats grown at McPherson, Kans., in the 5-year period from 1905 to 1909, inclusive.*

[Data obtained in cooperation with the Kansas Agricultural Experiment Station.]

Crop and variety.	C. I. No.	Yields per acre (pounds).						
		1905	1906	1907	1908	1909	Average.	
							1906 to 1908.	1905 to 1909.
Emmer:								
Black Winter	2337	470	1,332	778	1,925	1,180	1,345	1,137
Ufa	1527	.....	732	39	186	.....	319	.....
Vernal (White Spring)	1522	.....	924	54	159	.....	379	.....
Spelt:								
Red Winter	1772	835	1,230	890	1,500	1,060	1,207	1,103
Einkorn:								
Common (winter)	1781	237	981	216	.....	.....	.....	.....
Do	2226	414	1,044	486	852	0	794	559
Do	2433	336	1,050	114	.....	.....	.....	.....
Double (spring)	1780	.....	999	345	1,029	366	791	.....
Barley:								
Tennessee Winter	257	864	1,575	658	998	538	1,077	927
White Smyrna (spring)	195	1,358	2,430	158	1,070	1,094	1,219	1,222
Oats:								
Sixty-Day	165	1,081	1,392	150	1,568	1,696	1,037	1,177

RESULTS AT MANHATTAN, KANS.

The experiments at Manhattan, Kans., were conducted independently by the Kansas Agricultural Experiment Station. The yields of emmer and spelt have been published in part by Ten Eyck (*61*), Ten Eyck and Shoesmith (*62* p. 184), and in bulletins of the Kansas station. The yields obtained are shown in Table 9. The annual yields not given in the above-mentioned bulletins were furnished by courtesy of Prof. S. C. Salmon, in charge of farm-crop production at the Kansas Agricultural Experiment Station.

Vernal (White Spring) emmer was grown at Manhattan from 1903 to 1909, inclusive. Black Winter emmer and a variety of winter spelt also were grown at Manhattan, but for shorter periods. The yields of emmer and spelt, in comparison with barley and oats, are shown in Table 9. Both winter and spring barley and spring oats produced higher average yields than the spring emmer. Winter emmer produced fair yields in 1908, but this crop usually is not sufficiently winter hardy for growing at Manhattan.

Winter spelt produced good yields during each of the three years it was grown and exceeded both barley and oats in average yield during the 3-year period. Winter spelt, however, can not compete with winter wheat, the leading small-grain crop at Manhattan, neither is it likely to displace spring oats.

TABLE 9.—*Yields of two varieties of emmer, one of spelt, two of barley, and one of oats grown at Manhattan, Kans., in the 7-year period from 1903 to 1909, inclusive.*

Data compiled mostly from Kansas Agricultural Experiment Station Bulletins 123 and 166 (*61; 62*, p. 184).]

Crop and variety.	Yields per acre (pounds).								
	1903	1904	1905	1906	1907	1908	1909	Average.	
								1905 to 1909.	1903 to 1909.
Emmer:									
Black Winter					1,000	2,280			
Vernal (White Spring)	1,756	1,468	1,204	992	860	1,384	928	1,074	1,227
Spelt:									
Winter				2,284	2,572	2,128			
Barley:									
Tennessee Winter		1,642	3,897	3,211	682	1,570	3,150	2,502	
Select Mansury	1,416	1,464	2,030	619	1,540	2,180	2,410	1,756	1,666
Oats:									
Red Rustproof	1,376	486	2,045	1,434	1,446	1,200	2,038	1,633	1,432

RESULTS AT LA FAYETTE, IND.

Vernal emmer was grown at La Fayette, Ind., from 1910 to 1915. The yields, which were obtained independently by the Purdue University Agricultural Experiment Station, were published by Wiancko and Cromer (*66*) in Bulletin No. 225 of that station. These yields are shown in Table 10. Vernal emmer gave an average acre yield of 1,053 pounds during the five years. In the same years barley produced 1,130 pounds and oats 1,478 pounds per acre. Emmer can not be expected to equal oats in productiveness, and it is of only minor importance in the Corn Belt section.

TABLE 10.—*Yields of one variety each of spring emmer, barley, and oats grown at La Fayette, Ind., in 1910 and 1912 to 1915, inclusive.*

[Data compiled from Indiana Agricultural Experiment Station Bulletin 225 (*66*).]

Crop.	Yields per acre (pounds).					
	1910	1912	1913	1914	1915	Average.
Emmer: Vernal (White Spring)	1,288	1,589	792	418	1,176	1,053
Barley	2,194	1,815	350	307	984	1,130
Oats	1,271	2,255	1,130	499	2,233	1,478

RESULTS AT MADISON, WIS.

Vernal emmer was grown at Madison, Wis., for three years. The results were obtained independently by the Wisconsin Agricultural Experiment Station and were published by Moore (*32*) in the annual reports of that station. The yields of emmer and of barley and oats are shown in Table 11.

In the published reports the yields were given in bushels per acre, but the bushel weights used in calculating the yields of emmer were not stated. A weight of 40 pounds of emmer to the bushel has been assumed in converting bushels per acre into pounds per acre in Table 11.

Barley yielded more than twice as much as emmer at Madison. The yields of oats also were considerably higher than those of emmer, indicating that emmer can not compete with these two crops in southern Wisconsin.

TABLE 11.—*Yields of one variety each of spring emmer, barley, and oats grown at Madison, Wis., in 1899, 1900, and 1901.*

[Data compiled from the annual reports of the Wisconsin Agricultural Experiment Station (*32*). The yields of emmer in pounds are calculated at 40 pounds per bushel from the yields in bushels given in these reports.]

Crop and variety.	Yields per acre (pounds).			
	1899	1900	1901	Average.
Emmer: Vernal (White Spring)	1,060	1,200	1,160	1,140
Barley: Manchuria	2,372	2,842	2,097	2,430
Oats: Swedish Select	1,500	2,064	1,219	1,594

RESULTS AT ST. PAUL, MINN.

The experiments with emmer at University Farm, St. Paul, Minn., were conducted independently by the Minnesota Agricultural Experiment Station, and the results here reported are used by courtesy of that station. The yields shown in Table 12 were furnished to the writers by Prof. A. C. Arny, in charge of farm crops.

The 3-year average yield of Vernal (Minn. No. 1165) emmer is slightly less than that of Victory oats and considerably more than Improved Manchuria barley. Considering both yield and feeding value, the three crops are nearly equal. The results of the tests of only three years, however, are not conclusive.

TABLE 12.—*Yields of one variety each of spring emmer, barley, and oats grown at University Farm, St. Paul, Minn., in 1919, 1920, and 1921.*

[Data furnished by courtesy of the Minnesota Agricultural Experiment Station.]

Crop and variety.	Yields per acre (pounds).			
	1919	1920	1921	Average.
Emmer: Vernal (White Spring)	1,403	1,778	1,605	1,595
Barley: Improved Manchuria	1,710	1,340	1,292	1,447
Oats: Victory	1,392	2,046	1,410	1,616

RESULTS AT MORRIS, MINN.

Yields of emmer were obtained during three years at the West Central substation of the Minnesota Agricultural Experiment Station at Morris, Minn. The experiments were conducted independently by the Minnesota station and reported by Miller (*31*) in the 1918 report of the West Central substation. The yields are shown in Table 13.

Vernal emmer produced an average yield of 1,611 pounds per acre, which exceeded the yield of Improved Ligowa oats, but was considerably less than the yield of Manchuria barley. Barley appears to be the most productive of the three crops at Morris.

TABLE 13.— *Yields of one variety each of spring emmer, barley, and oats, grown at Morris, Minn., in 1916, 1917, and 1918.*

[Data compiled from the report of the West Central substation (*31*).]

Crop and variety.	Yields per acre (pounds).			
	1916	1917	1918	Average.
Emmer: Vernal (White Spring)	1,700	1,896	1,236	1,611
Barley: Manchuria (Minn. No. 105)	1,200	2,380	1,733	1,771
Oats: Improved Ligowa	1,008	2,370	1,302	1,560

RESULTS AT GRAND RAPIDS, MINN.

Vernal emmer was grown at Grand Rapids, Minn., in 1919, 1920, and 1921. The experiments were conducted independently by the Minnesota Agricultural Experiment Station, and the yields obtained in 1919 were given by Bergh (*3*) in the report of the Grand Rapids substation for that year. The yields obtained in 1920 and 1921 were furnished by Prof. A. C. Arny, of the Minnesota Agricultural Experiment Station.

As shown in Table 14, both barley and oats gave average yields distinctly higher than those of emmer at Grand Rapids. The yield of Vernal emmer was satisfactory in only one of the three years in which the crop was grown.

TABLE 14.— *Yields of one variety each of spring emmer, barley, and oats grown at Grand Rapids, Minn., in 1919, 1920, and 1921.*

[Data used by courtesy of the Minnesota Agricultural Experiment Station.]

Crop and variety.	Yields per acre (pounds).			
	1919	1920	1921	Average.
Emmer: Vernal (White Spring)	1,612	892	647	1,050
Barley: Improved Manchuria	1,800	1,637	696	1,378
Oats: Victory	1,098	1,882	1,069	1,350

RESULTS AT CROOKSTON, MINN.

Emmer was grown during eight years at Crookston, Minn., in the Red River Valley. The experiments were conducted independently by the Minnesota Agricultural Experiment Station. The yields were reported in part by Selvig (*46*) in the report of the Northwest Experiment Farm. The yields obtained in 1920 and 1921 were furnished by Prof. A. C. Arny, of the Minnesota Agricultural Experiment Station. The results at Crookston are shown in Table 15.

Vernal emmer produced a 7-year average yield of 1,403 pounds per acre, exceeding both barley and oats in two of the years tested. In the same seven years the average yields of barley and oats were 1,643 and 1,636 pounds per acre, respectively. Thus emmer is inferior in productiveness to both barley and oats at Crookston.

TABLE 15.— *Yields of one variety each of spring emmer, barley, and oats grown at Crookston, Minn., in the 9-year period from 1913 to 1921, inclusive, except 1917.*

[Data mostly compiled from the report of the superintendent, Northwest Experiment Station, 1913 to 1919 (*46*).]

Crop and variety	Yields per acre (pounds).								
	1913	1914	1915	1916	1918	1919	1920	1921	Average.[1]
Emmer: Vernal (White Spring)	1,620	1,084	1,560	920	2,220	1,524	1,702	712	1,403
Barley: Oderbrucker [2]	1,349	1,868	1,892	1,775	1,972	984	1,474	1,172	1,643
Oats: Lincoln [3]	1,516	1,760	3,014	746	1,494	(4)	2,035	890	1,636

[1] Seven-year average, 1919 omitted.
[2] Improved Manchuria barley in 1920 and 1921.
[3] Victory oats in 1920 and 1921.
[4] Destroyed by flooding.

RESULTS AT BROOKINGS, S. DAK.

The experiments at Brookings, S. Dak., were conducted cooperatively by the Office of Cereal Investigations and the South Dakota Agricultural Experiment Station. Emmer has been grown there since 1902. The data were reported in part by Champlin and Morrison (*10*). The yields obtained are shown in Table 16.

TABLE 16.— *Yields of five varieties of emmer and one variety each of einkorn, barley, and oats grown at Brookings, S. Dak., in stated years during the period from 1902 to 1919, inclusive.*

[Data obtained in cooperation with the South Dakota Agricultural Experiment Station.

Crop and variety	C. I. No.	Yields per acre (pounds).							
		1902	1904	1905	1906	1907	1908	1913	1914
Emmer:									
Vernal (White Spring)	1524	1,750	2,300	2,161	2,650	1,200	1,000	2,000	1,897
Do	1529	.....	.....	1,548	2,643	1,261	900	.....	.....
Do	2764	.....	.....	.....	1,590	1,120	1,000	.....	.....
Do. (S. Dak. No. 3)	2975	1,830	2,260	2,000	2,520	1,620	1,078	.....	.....
Yaroslav	1526	.....	2,315	1,940	2,630	1,190	707	.....	.....
Einkorn:									
Common	2433	.....	1,460	1,341	2,160	1,950	1,216	.....	.....
Barley:									
Manchuria	[1] 241	.....	2,080	2,352	1,968	1,660	1,316	3,110	2,555
Oats:									
Sixty-Day	165	.....	2,227	2,560	1,971	781	1,894	2,880	1,652

Crop and variety.	C. I. No.	Yields per acre (pounds).							
							Average.		
		1915	1916	1917	1918	1919	1904 to 1908.	1904 to 1908 and 1915 to 1919.	1904 to 1919.[2]
Emmer:									
Vernal (White Spring)	1524	2,202	1,600	1,705	2,000	1,100	1,862	1,792	1,818
Do	1529	.....	.....	.....	.....	.....	.....	.....	.....
Do	2764	.....	.....	.....	.....	.....	.....	.....	.....
Do. (S. Dak. No. 3)	2975	.....	.....	.....	.....	.....	1,896	.....	.....
Yaroslav	1526	2,500	701	1,705	1,520	851	1,756	1,606	.....
Einkorn:									
Common	2433	.....	.....	.....	.....	.....	1,625	.....	.....
Barley:									
Manchuria	[1] 241	2,950	2,102	2,200	2,702	1,050	1,875	2,038	2,170
Oats:									
Sixty Day	165	2,698	2,332	1,926	2,100	1,550	1,887	2,004	2,048

[1] Manchuria (C. I. No. 241) 1904 to 1908, inclusive, and C. I. No. 244, 1913 to 1919, inclusive.
[2] Crop destroyed by hail in 1903. Emmer not grown 1909 to 1912, inclusive.

Several practically identical lots of Vernal emmer produced very similar yields. The Yaroslav variety, apparently identical with Vernal, yielded an average of 186 pounds per acre less than Vernal during the years in which Yaroslav was grown. Common einkorn was grown from spring sowing for five years, but it yielded distinctly less than the other crops. Emmer was not grown during the years 1909 to 1921, inclusive. During the remainder of the years from 1904 to 1919, inclusive, Vernal emmer produced an average yield of 1,818 pounds per acre. The average acre yields of Manchuria barley and Sixty-Day oats during the same years were 2,038 and 2,004 pounds, respectively. Emmer evidently can not compete with barley and oats under the conditions obtaining at Brookings, although it occasionally gives higher yields than either of these crops.

RESULTS AT FARGO, N. DAK.

Experiments with emmer were begun at Fargo, N. Dak., in 1898, earlier than at most of the stations here included. The results obtained by the North Dakota Agricultural Experiment Station, mostly in cooperation with the Office of Cereal investigations previous to 1907, were reported by Shepperd and Churchill (*47*) in Bulletin No. 75 of the North Dakota Agricultural Experiment Station. The yields obtained since that time have not yet been published and are used here by courtesy of the North Dakota Agricultural Experiment Station, the data being furnished by T. E. Stoa, assistant agronomist of that station.

Vernal emmer was grown continuously from 1898 to 1913, inclusive, but the crop was drowned out in 1905 and 1909. Two other varieties of emmer and one variety each of spelt and einkorn, the yields of which are not shown, were grown during several years, but they yielded considerably less than the Common or Vernal emmer. The annual and average yields of Vernal emmer compared with barley and oats at Fargo are shown in Table 17.

TABLE 17.—*Yields of spring emmer, barley, and oats grown at Fargo, N. Dak., in stated years during the period from 1898 to 1913, inclusive.*[1]

[Data mostly used by courtesy of the North Dakota Agricultural Experiment Station.]

Crop and variety.	Yields per acre (bushels).						
	1898	1899	1900	1901	1902	1903	1904
Emmer: Vernal (White Spring; N. Dak. No. 305)	2,336	2,212	1,348	2,344	3,252	1,864	1,840
Barley: Manchuria (N. Dak. No. 871)[2]	2,304	2,415	600	2,162	2,673	1,891	1,517
Oats: Lincoln	2,205	2,173	858	1,840	1,085	2,115	2,096

Crop and variety.	Yields per acre (pounds).							
	1906	1907	1908	1910	1911	1912	1913	Average.
Emmer: Vernal (White Spring; N. Dak. No. 305)	900	3,120	2,528	2,668	1,148	1,980	1,992	2,109
Barley: Manchuria (N. Dak. No. 871)[2]	720	2,918	2,928	1,646	821	2,357	3,192	2,010
Oats: Lincoln	1,398	1,760	3,040	1,699	1,149	2,858	2,474	1,911

[1] Crop drowned out in 1905 and 1909.
[2] Yields of Manchuria (Mansury) barley (N. Dak. No. 252) used from 1898 to 1900, inclusive.

Vernal emmer produced an average acre yield of 2,109 pounds, barley 2,010 pounds per acre, and oats 1,911 pounds per acre. Considering both yield and feeding value, emmer and barley are nearly equal and are superior to oats. Fargo is the only station at which emmer has been found to outyield both barley and oats. It is not believed that emmer should replace those crops even in this section.

RESULTS AT GUELPH, ONTARIO.

Extensive experiments with emmer and spelt have been conducted at the Ontario Agricultural College, Guelph, Ontario. Average data from these have been reported from time to time in bulletins and annual reports from the field-husbandry department of the college. Average yields, percentages of hull, rust, and lodging, and bushel weight of four lots each of emmer and spelt were published by Zavitz (*71*) in 1919. These data are shown in Table 18. The lots of emmer were all of the Vernal (White Spring) variety and were practically identical, but were obtained from different sources. The yields obtained were similar, the most productive lot yielding 2,779 bushels per acre. The highest yielding variety of spelt, Alstroum, yielded 2,140 pounds per acre. The Alstroum and the Red spelt are the varieties grown from fall sowing in Maryland and Virginia, but they mature seed as well when sown in the spring. The emmer and spelt varieties were all sown in the spring at Guelph.

TABLE 18.—*Average data obtained on four lots each of emmer and spelt grown at Guelph, Ontario, during 13 years.*

[Data compiled from Ontario Agricultural College Bulletin 268 (*71*).]

Crop and variety.	Hull.[1]	Rust.	Lodging.	Bushel weight.	Yields per acre.	
					Straw.	Grain.
Emmer:	*Per cent.*	*Per cent.*	*Per cent.*	*Pounds.*	*Tons.*	*Pounds.*
Vernal (White Spring)	19.75	2	21	39.58	1.93	2,779
Do	19.54	2	14	39.17	1.89	2,738
Vernal (Russian)	19.96	2	15	39.59	1.75	2,712
Vernal (Iowa)	19.10	2	18	39.69	1.78	2,680
Spelt:						
Alstroum	28.65	13	4	27.40	1.52	2,140
Red	28.14	10	7	27.88	1.53	2,117
White Spring	29.17	13	3	27.26	1.56	2,087
White Bearded	26.07	10	14	29.35	1.57	2,061

[1] Average for 12 years.

Both winter and spring wheat are grown in Ontario, but winter wheat is the more productive in the vicinity of Guelph. All of the barley and oats grown commercially in Ontario are spring sown. Spring emmer has been grown in an experiment at Guelph along with several other crops for a period of 18 years, with directly comparable results. The average total yields and total digestible constituents of spring emmer, barley, and oats during the 18-year period are shown in Table 19. The total yields of each crop represent the average of two varieties. The yields of digestible nutrients shown are the product of the total yields and the percentages of the digestible nutrients in each crop. The data were published by Zavitz (*71*) in 1919. The total yields of both barley and oats were higher than those of emmer. In its content of digestible nutrients emmer exceeded oats but was inferior to barley.

TABLE 19.—*Yields of grain and digestible constituents of two varieties each of spring emmer, barley, and oats grown at Guelph, Ontario, during the 18-year period from 1901 to 1918, inclusive.*

[Data compiled from Ontario Department of Agriculture Bulletin 268 (71).]

Crop.	Average yields per acre (pounds).	
	Grain.	Digestible constituents.
Emmer (two varieties)	2,548	1,895.7
Barley (two varieties)	2,673	2,069.0
Oats (two varieties)	2,591	1,699.7

During the period from 1913 to 1919, inclusive, 109 cooperative trials of emmer in comparison with barley were conducted by farmers in Ontario under the supervision of Dr. C. A. Zavitz. The annual and average acre yields of the two crops, as reported by Zavitz (*72*), are shown in Table 20. The yields of barley exceeded those of emmer in each year, the average difference being 281 pounds per acre. Both emmer and spelt are less productive than either barley or oats in Ontario.

TABLE 20.—*Yields of Vernal emmer and O. A. C. No. 21 barley, grown in 109 cooperative experiments by members of the Ontario Agricultural and Experimental Union during the 7-year period from 1913 to 1919, inclusive.*

[Data compiled from the 41st Annual Report of the Ontario Agricultural and Experimental Union (*72*).]

Crop and variety.	Yields per acre (pounds).							
	1913	1914	1915	1916	1917	1918	1919	Average.
Emmer: Vernal (White Spring)	1,191	1,359	1,673	1,080	1,705	1,566	1,000	1,368
Barley: O. A. C. No. 21	1,613	1,714	2,022	1,220	1,794	2,138	1,040	1,649

RESULTS AT OTTAWA, ONTARIO.

Experiments with emmer were begun at Ottawa, Ontario, in 1901. From 1903 to 1914 rather extensive experiments with emmer, spelt, and einkorn were in progress. The results of these have been published by Saunders (*39* and *41*) in the annual reports of the Dominion cerealist and are shown in Table 21. No emmer or spelt was grown in 1913.

Vernal (White Spring) emmer yielded nearly the same as Red emmer and somewhat more than any of the varieties of spelt. Two varieties of einkorn were grown at Ottawa during the period of the experiments, one from 1903 to 1905 and the other from 1906 to 1914. The Common variety outyielded both emmer and spelt during two of the three years it was grown. The Double einkorn yielded an average of 113 pounds per acre less than Vernal emmer during the eight years from 1906 to 1914 (1913 excluded).

The average acre yield of Vernal emmer during the 12 years from 1901 to 1912, inclusive, was 2,001 pounds. During the same period Stella barley averaged 2,487 pounds and Banner oats 2,338 pounds per acre.

TABLE 21.— *Yields of six varieties of emmer, five of spelt, two of einkorn, and one each of barley and oats grown at the Central Experimental Farm, Ottawa, Ontario, during the period from 1901 to 1914, inclusive.*[1]

[Data compiled from reports of the Dominion Experimental Farms (*39* and *41*).]

Crop and variety.	Ottawa No.	Yields per acre (pounds).						
		1901	1902	1903	1904	1905	1906	1907
Emmer:								
Vernal (White Spring)		1,310	1,800	1,300	2,040	2,060	2,720	2,520
Ufa				1,320				
White	1981			1,540	2,540	1,920	1,500	1,410
Thick	1984			1,020	1,980	2,060	1,400	1,740
Long	1994			1,760	1,220	1,660		
Red	1989			1,740	2,760	1,880	2,680	1,950
Spelt:								
Red	1990			2,660	2,240	1,620	2,100	2,190
Smooth	1993			2,380	2,260	2,120	1,800	2,850
White	1991			1,940	1,740	2,400	1,740	2,430
White Bearded	1995			1,600	1,680	1,620	1,200	1,950
Black Bearded	1985			1,580				
Einkorn:								
Common				2,720	3,060	1,380		
Double							2,540	2,310
Barley:								
Stella[2]		1,720	3,160	2,460	2,800	2,660	2,260	2,460
Oats:								
Banner[3]		1,640	2,760	2,420	2,360	2,860	2,340	2,760

Crop and variety.	Ottawa No.	Yields per acre (pounds).						Average.	
		1908	1909	1910	1911	1912	1914	1903 to 1912.	1901 to 1912.
Emmer:									
Vernal (White Spring)		810	3,090	2,520	1,920	1,920	1,770	2,090	2,001
Ufa									
White	1981	360							
Thick	1984	570							
Long	1994								
Red	1989	630	2,250	2,040	1,920	3,030	3,000	2,088	
Spelt:									
Red	1990	720	1,800	1,410	1,440	1,980		1,816	
Smooth	1993	750	1,740	2,820	1,320	2,130	2,940	2,017	
White	1991	390	1,830	2,550	1,290	2,520		1,883	
White Bearded	1995								
Black Bearded	1985								
Einkorn:									
Common									
Double		990	2,520	2,070	2,160	2,460	1,320		
Barley:									
Stella[2]		2,720	1,680	2,940	2,760	2,220		2,496	2,487
Oats:									
Banner:[3]		2,040	1,980	2,670	2,640	1,590	1,980	2,366	2,338

[1] Emmer and spelt were not grown in 1913.
[2] Stella Selection G grown from 1910 to 1912, inclusive.
[3] Banner Selection A in 1906 and 1907; Selection B, 1908 to 1912, inclusive; and Selection M in 1914.

RESULTS AT NAPPAN, NOVA SCOTIA.

Three varieties each of emmer and spelt have been grown at Nappan, Nova Scotia. The Red spelt slightly outyielded the White Spring spelt, as well as all varieties of emmer. Both emmer and spelt averaged considerably less than barley and oats. The data, taken from the annual reports of the Dominion cerealist (*39* and *41*), are shown in Table 22.

TABLE 22.—*Yields of three varieties each of emmer and spelt and one variety each of barley and oats grown on the Nappan (Nova Scotia) Experimental Farm in all or part of the years from 1900 to 1910, inclusive.*

[Data compiled from reports of Dominion Experimental Farms (*39* and *41*).]

Crop and variety.	Yields per acre (pounds).												
												Average.	
	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1900 to 1910.	1904 to 1910.
Emmer:													
Vernal (White Spring)	2,680	1,680	2,600	1,520	1,040	2,400	1,760	1,860	2,240	1,480	2,600	1,987	1,911
White	.....	.....	.....	1,400	.....	.....	.....	.....	.....	.....	.....	.....	.....
Red	.....	.....	.....	.....	1,000	1,120	1,040	1,280	1,560	1,360	2,680	.....	1,434
Spelt:													
White Spring	.....	.....	.....	1,760	1,120	2,360	2,120	1,800	1,480	1,600	3,500	.....	1,997
White Bearded	.....	.....	.....	1,720	.....	.....	.....	.....	.....	.....	.....	.....	.....
Red	.....	.....	.....	.....	1,400	2,440	1,880	2,040	2,000	1,400	3,120	.....	2,040
Barley:													
Mansury	2,880	2,720	2,400	2,880	2,360	2,320	2,080	2,000	2,060	2,480	2,400	2,416	2,245
Oats:													
Banner	2,520	2,160	3,080	3,240	2,180	2,560	1,520	2,520	2,340	1,920	2,680	2,429	2,246

RESULTS IN THE GREAT PLAINS AREA.

The Great Plains area extends from the ninety-eighth meridian of longitude westward to the Rocky Mountains and from southern Texas northward into Canada. The altitude varies from about 1,000 feet on the eastern border to about 6,000 feet at the foothills of the Rocky Mountains. The soils of the Great Plains area vary from light sandy loams to heavy clays or gumbos.

The annual precipitation ranges from about 14 inches in the northwestern portion to nearly 25 inches in central Texas. The area is semiarid, generally speaking, as evaporation is so high, even where the rainfall is greatest, that soil moisture is the chief limiting factor in crop production. From half to two-thirds of the precipitation comes during the growing season, from April to August, inclusive. Wind movement is rapid, summer temperatures are high, and the loss of water by evaporation is heavy. Hot winds, hail, and rust occur occasionally in the Great Plains area and are important factors influencing the production of small grains.

Winter wheat is the leading small-grain crop in the southern half of the Great Plains area and spring wheat in the northern half. Because of the severe winter temperatures practically all of the barley and oats grown in the Great Plains area is spring sown, although winter barley and oats can be grown in the southern portion of the area.

Both winter and spring emmer have been grown in experiments in the Great Plains area. The yields at most stations are compared only with those of spring varieties of barley and oats, however, because these crops could not be grown from fall sowing.

Experiments with emmer were begun in the Great Plains about 1900. Results obtained at 22 experiment stations in this area, 17 in the United States and 5 in Canada, are shown in this bulletin. It contains nearly all of the results with emmer in the Great Plains area, except limited tests in Wyoming and Montana. At the Judith Basin substation, Moccasin, Mont., Donaldson (*16*) showed that emmer did not compare favorably with other crops.

RESULTS AT AMARILLO, TEX.

The experiments at Amarillo, Tex., were conducted by the Office of Cereal Investigations in cooperation with the Amarillo Chamber of Commerce. The yields have been reported in part by Ross and Leidigh (*35*). Winter emmer and spelt were grown at Amarillo from 1906 to 1919, inclusive. During this period the average acre yield of Black Winter emmer was 418 pounds and of Red Winter spelt 461 pounds, as shown in Table 23. Tennessee Winter barley yielded an average of 660 pounds per acre during the same years. Because of the severe winter temperatures which are common in the Panhandle section of Texas, winter oats can not be grown at Amarillo. Algerian spring oats, however, produced an average yield of 622 pounds per acre.

None of those crops has proved profitable at Amarillo because of drought, hot winds, and winterkilling. Winter wheat has been the most productive small grain at that station. Red Winter spelt is slightly hardier and more productive than Black Winter emmer, but neither of these crops is as productive as barley and oats.

TABLE 23.—*Yields of three varieties of emmer and one variety each of spelt, barley, and oats grown at the Amarillo Cereal Field Station, Amarillo, Tex., during the period from 1906 to 1919.*[1]

[Data obtained in cooperation with the Amarillo Chamber of Commerce.]

Crop and variety.	C. I. No.	Yields per acre (pounds).													
		1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1919	Average.
Emmer:															
Black Winter	2337	1,135	203	768	0	603	238	120	80	510	580	188	673	753	418
Do	4483	.....	340	570	70	583	225	110	80	720	540	235	603	740	.....
Buffum Black Winter	3331	.....	....	.....	....	....	....	370	83	780	590	330	400	.....	.....
Spelt:															
Red Winter	1772	1,243	360	1,270	0	380	520	160	68	0	1,020	95	428	908	461
Barley:															
Tennessee Winter	257	1,147	0	1,080	0	149	677	451	470	1,830	1,100	317	782	1,234	660
Oats:															
Algerian	286	502	563	1,219	570	365	573	892	246	1,328	796	237	0	1,415	622

[1] Failure in 1918.

RESULTS AT CHANNING, TEX.

The experiments at Channing, Tex., were conducted by the Office of Cereal Investigations in cooperation with the Capitol Freehold Land & Investment Co. The yields given in Table 24 have been previously published by Ross and Leidigh (*35*). The conditions at Channing are very similar to those at Amarillo. The one variety of emmer, Black Winter, grown at Channing in 1905 and 1906 produced an average yield of 1,029 pounds per acre. Tennessee Winter barley yielded 1,054 pounds per acre and Burt spring oats 835 pounds per acre during the same period. In 1905, the only year grown, einkorn produced 207 pounds of grain per acre. As at Amarillo, winter wheat was the most profitable small-grain crop, and it produced more than either emmer, barley, or oats.

TABLE 24.—*Yields of one variety each of emmer, einkorn, barley, and oats grown at the XIT ranch, Channing, Tex., in 1905 and 1906.*

[Data obtained in cooperation with the Capitol Freehold Land & Investment Co.]

Crop and variety.	C. I. No.	Yields per acre (pounds).		
		1905	1906	Average.
Emmer: Black Winter	2337	1,280	778	1,029
Einkorn: Common	2433	207	.....	.....
Barley: Tennessee Winter	261	547	1,560	1,054
Oats: Burt	293	826	844	835

RESULTS AT HAYS, KANS.

Winter wheat and spring barley are the leading small-grain crops in the vicinity of Hays, Kans. The experiments at the Fort Hays branch station have been conducted cooperatively by the Kansas Agricultural Experiment Station and the Office of Cereal Investigations. The results obtained in the six years from 1913 to 1918 are shown in Table 25. Black Winter emmer had produced an average yield of 504 pounds per acre. Mariout barley produced more and a hybrid oat, Burt × Sixty-Day, which has not been distributed, considerably less than the emmer. Red Winter spelt outyielded the Black Winter emmer during the years in which the former was grown, but yielded less than the barley.

TABLE 25.—*Yields of three varieties of emmer and one variety each of spelt, barley, and oats grown at Hays, Kans., in all or part of the six years from 1913 to 1918, inclusive.*

[Data obtained in cooperation with the Kansas Agricultural Experiment Station.]

Crop and variety.	C. I. No.	Yields per acre (pounds).							
		1913	1914	1915	1916	1917	1918	Average.	
								1914 to 1918.	1913 to 1918.
Emmer:									
Black Winter	2337	450	702	498	978	0	396	515	504
Black Winter (Nebraska)	.....	.....	1,248	.....	.....	.....	.....	.....	.....
Buffum Black Winter	3331	.....	240	.....	.....	.....	.....	.....	.....
Spelt:									
Red Winter	.....	.....	726	750	804	534	276	618	.....
Barley:									
Mariout	261	115	1,042	1,435	466	0	960	781	670
Oats:									
Burt × Sixty-Day	727	186	589	723	397	0	483	438	396

RESULTS AT AKRON, COLO.

The experiments at Akron, Colo., were conducted by the Office of Cereal Investigations in cooperation with the Office of Dry-Land Agriculture Investigations of the Bureau of Plant Industry. The yields have been published in part by McMurdo (*27*). The results obtained in the period from 1908 to 1921 are shown in Table 26. The Black Winter emmer was grown in nine years, but yielded less than half as much as the Vernal (White Spring) variety. It was entirely winterkilled in three seasons.

Vernal emmer was grown in each of the 14 years and produced an average yield of 762 pounds per acre. During the same period Hannchen barley produced 1,477 pounds and Kherson oats 1,075 pounds per acre. Khapli emmer yielded slightly more than the Vernal variety during the two years it was grown.

At Akron and in the surrounding portion of northeastern Colorado the winters are too severe for winter emmer or winter spelt to be successfully grown. Spring emmer can be grown, but it is much less productive than the best varieties of barley and oats.

TABLE 26.— *Yields of four varieties of emmer, two varieties of spelt, and one variety each of barley and oats grown at Akron, Colo., in some or all of the 14 years from 1908 to 1921, inclusive.*

[Data obtained in cooperation with the Office of Dry-Land Agriculture Investigations.]

Crop and variety.	C. I. No.	Yields per acre (pounds).							
		1908	1909	1910	1911	1912	1913	1914	1915
Emmer:									
Black Winter	2337	944	0	554	784	585	448	400	0
Buffum Black Winter	3331						628	298	
Vernal (White Spring)	1524	838	1,363	355	621	1,206	509	659	2,208
Khapli	4013								
Spelt:									
Alstroum	1773								
White Bearded	1724								
Barley:									
Hannchen[1]	602	2,295	994	1,353	499	1,665	1,060	2,860	4,128
Oats:									
Kherson	459	1,690	1,059	1,187	397	1,152	1,155	2,080	2,720

Crop and variety.	C. I. No.	Yields per acre (pounds).						Average.	
		1916	1917	1918	1919	1920	1921	1908 to 1916	1908 to 1921.
Emmer:									
Black Winter	2337	0						413	
Buffum Black Winter	3331					0			
Vernal (White Spring)	1524	435	454	147	314	1,360	202	910	762
Khapli	4013	538					227		
Spelt:									
Alstroum	1773						0		
White Bearded	1724						0		
Barley:									
Hannchen[1]	602	1,147	821	658	495	1,825	874	1,778	1,477
Oats:									
Kherson	459	538	470	195	358	1,254	790	1,331	1,075

[1] Yields of White Smyrna barley, 1915 to 1921, inclusive.

RESULTS AT NORTH PLATTE, NEBR.

The experiments at the North Platte substation of the Nebraska Agricultural Experiment Station were conducted independently by the State. The results shown in Table 27 were taken from Nebraska Agricultural Experiment Station Bulletins Nos. 118, 135, and 172, published by Snyder and Burr (*53*, *54*) and by Zook (*73*). During the 10-year period from 1909 to 1918 a combination date-of-seeding experiment was conducted with spring wheat, oats, barley, and

emmer. The average yields from all dates of seeding of the emmer, barley, and oats, together with additional yields in 1907 and 1908, are shown in Table 27.

The average yield of Vernal (White Spring) emmer during the entire period was 699 pounds per acre, in comparison with 1,103 pounds of barley and 899 pounds of oats. Black Winter emmer was sown several years and was occasionally successful, but during most winters it was partly or entirely winterkilled.

TABLE 27.—*Yields of one variety each of spring emmer, barley, and oats grown at North Platte, Nebr., in the 12-year period from 1907 to 1918, inclusive.*

Data compiled from Nebraska Agricultural Experiment Station Bulletins 118, 125, and 172 [illegible]

Crop and variety.	Yields per acre (pounds).												
	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	Average.
Emmer:													
Vernal (White Spring)	1,718	2,024	1,534	431	0	291	66	142	1,488	414	167	103	699
Barley:													
Manchuria	2,226	2,284	1,858	630	0	708	374	505	1,352	1,222	[1] 1,258	[1] 823	1,103
Oats:													
Kherson	1,442	2,044	1,646	354	0	648	149	282	1,419	1,288	687	836	899

[1] White Smyrna barley.

RESULTS AT ARCHER, WYO.

Both winter and spring emmer were grown at the Cheyenne field station, near Archer, Wyo., in the seven years from 1913 to 1919, inclusive. The experiments were conducted by the Office of Cereal Investigations in cooperation with the Wyoming State Board of Farm Commissioners and more recently with the Wyoming Agricultural Experiment Station. The yields, which have been published in part by Jones (*21*), are given in Table 28.

Vernal spring emmer yielded an average of 702 pounds per acre in comparison with 1,074 pounds of Hannchen barley and 893 pounds of Abundance oats. Black Winter emmer survived only two of the seven winters.

TABLE 28.—*Yields of two varieties of emmer and one each of barley and oats grown at Archer, Wyo., in the 7-year period from 1913 to 1919, inclusive.*

[Data obtained in cooperation with the Wyoming State Board of Farm Commissioners.]

Crop and variety.	C. I. No.	Yields per acre (pounds).							
		1913	1914	1915	1916	1917	1918	1919	Average.
Emmer:									
Black Winter	2,337	454	0	173	0	0	0	0	90
Vernal (White Spring)	1,524	230	429	864	346	1,175	1,600	269	702
Barley:									
Hannchen	531	461	768	1,637	379	1,387	2,702	182	1,074
Oats:									
Abundance	731	240	650	1,676	224	1,161	2,175	125	899

RESULTS AT JIREH, WYO.

The conditions at Jireh, Wyo., are very similar to those at Archer. The experiments were conducted independently by the State. The yields shown in Table 29 were taken from the report of the State cooperative experiment farms (*34*). The data are rather incomplete, but they show the yields of spring emmer and oats for three years and of barley for one year. Vernal emmer produced an average yield of 740 pounds per acre in comparison with 981 pounds of Kherson oats. Hannchen barley outyielded both emmer and oats by a considerable margin in 1915, the only year in which yields of barley were reported. Black Winter emmer was sown, but winterkilled each year.

TABLE 29.—*Yields of one variety each of spring emmer, barley, and oats grown at the State experiment farm, Jireh, Wyo., in 1915, 1916, and 1918.*

[Data compiled from report of the State Board of Farm Commissioners, Cheyenne, Wyo. (*34*).]

Crop and variety.	Yields per acre (pounds).			
	1915	1916	1918	Average.
Emmer: Vernal (White Spring)	1,220	560	440	740
Barley: Hannchen	2,496			
Oats: Kherson	1,535	768	640	981

RESULTS AT SHERIDAN, WYO.

Comparable results obtained at Sheridan, Wyo, in 1915 by the Wyoming State Board of Farm Commissioners were published in the report of the State cooperative experiment farms for 1915 (*34*). Vernal emmer yielded 880 pounds per acre, while Beardless barley produced 2,016 pounds and Kherson oats produced 1,600 pounds.

RESULTS AT HIGHMORE, S. DAK.

Experiments with emmer were begun at Highmore, S. Dak., in 1903. The data were obtained cooperatively by the Office of Cereal Investigations and the South Dakota Agricultural Experiment Station. Average yields of emmer at Highmore were published by Champlin and Morrison (*10*) in South Dakota Agricultural Experiment Station Bulletin No. 179. Vernal emmer was grown during the entire 16-year period from 1903 to 1918, with an average yield of 1,230 pounds per acre, as shown in Table 30. During the same period White Smyrna barley yielded 1,223 pounds and Sixty-Day oats 1,235 pounds per acre. The average yields of the three crops are nearly identical. Emmer appears to be best adapted to conditions similar to those at Highmore. When feeding values are considered, emmer is a less valuable crop than barley but is superior to oats. As emmer outyields both barley and oats in some years, it may be desirable to include it in the rotation and thus spread the crop risks, but on the whole it is less satisfactory than barley.

Of the other varieties of emmer which were grown for a part of the period, the Yaroslav yielded less and the Khapli slightly more than the Vernal. Black Winter emmer, although sown in several years,

was unable to survive any of the winters. Common einkorn was grown at Highmore for three seasons, but it yielded considerably less than barley, oats, or emmer.

TABLE 30.— *Yields of three varieties of emmer and one variety each of einkorn, barley, and oats grown at Highmore, S. Dak., in the 16-year period from 1903 to 1918, inclusive.*

[Data obtained in cooperation with the South Dakota Agricultural Experiment Station.]

Crop and variety.	C. I. No.	Yields per acre (pounds).							
		1903	1904	1905	1906	1907	1908	1909	1910
Emmer:									
Vernal	2,975	1,030	1,660	2,410	1,560	1,430	1,350	660	840
Yaroslav	1,526	.....	.....	2,208	.....	.....	.....	.....	.....
Khapli	4,013	.....	.....	.....	.....	.....	.....	.....	.....
Einkorn:									
Common	2,433	.....	.....	1,088	1,088	.....	931	.....	.....
Barley:									
White Smyrna	195	797	797	2,180	1,460	940	1,430	940	672
Oats:									
Sixty-Day	165	771	1,321	2,051	1,385	1,011	1,520	922	300

Crop and variety.	C. I. No.	Yields per acre (pounds).								
		1911	1912	1913	1914	1915	1916	1917	1918	Average, 1903 to 1918.
Emmer:										
Vernal	2,975	[1] 0	19	125	1,650	3,200	1,550	1,150	1,052	1,230
Yaroslav	1,526	.....	.....	.....	.....	.....	1,450	1,000	.....	.....
Khapli	4,013	.....	.....	.....	.....	.....	1,700	1,000	1,107	.....
Einkorn:										
Common	2,433	.....	.....	.....	.....	.....	.....	.....	.....	.....
Barley:										
White Smyrna	195	[1] 0	413	518	1,820	2,895	2,000	1,450	1,248	1,223
Oats:										
Sixty-Day	165	[1] 0	38	291	1,625	4,100	2,200	825	1,392	1,235

[1] Failure in 1911.

RESULTS AT EUREKA, S. DAK.

Experiments with emmer were begun by the South Dakota Agricultural Experiment Station at the Eureka substation in 1912, in cooperation with the Office of Cereal Investigations. The results have been published in part in South Dakota Bulletin No. 179 (*10*). The yields obtained are shown in Table 31. Vernal emmer produced an average yield of 1,170 pounds per acre in comparison with 1,290 pounds of Hannchen barley and 1,309 pounds of Sixty-Day oats.

RESULTS AT COTTONWOOD, S. DAK.

The results of experiments with Vernal emmer conducted at the Cottonwood substation by the South Dakota Agricultural Experiment Station in cooperation with the Office of Cereal Investigations during the four years from 1916 to 1919, inclusive, also are shown in Table 31. Vernal emmer produced an average yield of 966 pounds per acre. During the same period Odessa barley yielded 1,153 pounds and Sixty-Day oats 1,104 pounds per acre.

TABLE 31.— *Yields of one variety each of spring emmer, barley, and oats grown at Eureka and Cottonwood, S. Dak., in the 8-year period from 1912 to 1919, inclusive.*

[Data obtained in cooperation with the South Dakota Agricultural Experiment Station.]

Crop and variety.	C. I. No.	Yields per acre (pounds).								
		1912	1913	1914	1915	1916	1917	1918	1919	Average.
EUREKA.										
Emmer: Vernal (White Spring)	2975	160	1,280	1,150	2,905	1,730	1,127	10	1,000	1,170
Barley: Hannchen	531	75	1,183	1,943	3,285	1,795	1,150	34	853	1,290
Oats: Sixty-Day [1]	165	195	670	725	3,245	2,555	1,610	86	1,390	1,309
COTTONWOOD.										
Emmer: Vernal (White Spring)	1524	.....	.....	.....	.....	1,070	380	1,365	1,050	966
Barley: Odessa	182	.....	.....	.....	.....	1,240	555	1,025	1,790	1,153
Oats: Sixty-Day	165	.....	.....	.....	.....	930	710	1,334	1,440	1,104

[1] Swedish Select oats in 1913 and 1914.

RESULTS AT NEWELL, S. DAK.

Emmer and spelt have been grown on both dry and irrigated land on the Belle Fourche Experiment Farm at Newell, S. Dak. The experiments were conducted by the Office of Cereal Investigations in cooperation with the Office of Western Irrigation Agriculture, Bureau of Plant Industry, and since 1912 with the South Dakota Agricultural Experiment Station. The yields have been reported in part by Salmon (*37*) and Martin (*30*) and are presented in Table 32.

TABLE 32.— *Yields of two varieties of emmer and one variety each of spelt, barley, and oats grown on dry land at Newell, S. Dak., in all or part of the 12 years from 1908 to 1919, inclusive, and of the same number of varieties of these crops grown on irrigated land during the eight years from 1912 to 1919, inclusive.*

[Data obtained in cooperation with the Office of Western Irrigation Agriculture and the South Dakota Agricultural Experiment Station.]

Crop and variety.	C. I. No.	Yields per acre (pounds).												Average	
		1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1913 to 1918	1908 to 1919
DRY LAND.															
Emmer:															
Buffum Black Winter	3331	.....	.....	.....	.....	.....	1,035	1,248	848	625	0	0	.....	626	.....
Vernal (White Spring)	1524	1,430	975	14	0	0	500	0	3,513	1,100	781	684	285	1,096	774
Spelt: Red Winter	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	100	0	.....	.....	.....
Barley: Hannchen [1]	531	1,392	922	149	0	0	609	321	4,123	1,133	840	1,133	293	1,360	910
Oats: Kherson	459	1,507	822	480	0	198	700	442	3,547	1,305	1,081	1,210	141	1,381	953
IRRIGATED.														1912 to 1919	
Emmer:															
Buffum Black Winter	3331	.....	.....	.....	.....	.....	.....	.....	.....	425	0	.....	.....	.....	.....
Vernal (White Spring)	1524	.....	.....	.....	.....	784	889	1,088	1,855	1,141	1,845	2,816	1,900	1,539	.....
Spelt: Red Winter	.....	.....	.....	.....	.....	.....	.....	.....	.....	100	0	.....	.....	.....	.....
Barley: Chevalier II	530	.....	.....	.....	.....	[2] 624	1,580	1,104	1,881	1,150	1,848	3,567	1,536	1,661	.....
Oats: White Russian	551	.....	.....	.....	.....	1,325	1,078	1,555	1,690	1,347	1,798	2,410	2,016	1,652	.....

[1] Hanna (C. I. No. 24) in 1908.
[2] Yield of Hannchen (C. I. No. 531) substituted as Chevalier II was not grown.

Winter emmer and winter spelt were not grown on the dry land in all seasons. Neither of these crops is hardy enough for western South Dakota. Buffum Black Winter emmer during the six years from 1913 to 1918 yielded somewhat more than half as much as Vernal spring emmer. The average yield of Vernal emmer in the 12 years from 1908 to 1919, inclusive, was 774 pounds per acre. During the same period Hannchen barley yielded 910 pounds and Kherson oats 953 pounds per acre. The less productive varieties of barley and oats did not outyield the emmer. During seasons of severe drought, as in 1914 and 1917, emmer was less productive than barley and oats.

The experiments on irrigated land were begun in 1912. Vernal emmer produced an average yield of 1,539 pounds per acre in comparison with 1,661 pounds of Chevalier II barley and 1,652 pounds of White Russian oats. Buffum Black Winter emmer and Red Winter spelt were sown in 1915 and 1916. Both were badly winterkilled during the winter of 1915–16 and entirely destroyed during the following winter.

RESULTS AT HETTINGER, N. DAK.

Yaroslav spring emmer was grown at Hettinger, N. Dak., during two seasons. The results obtained independently by the North Dakota Agricultural Experiment Station were reported by Ogaard (*33*) in Bulletin No. 130 of that station. The yields of emmer in comparison with barley and oats are shown in Table 33. Emmer produced a higher yield than oats but lower than that of barley. The 2-year data are not sufficient for definite conclusions.

TABLE 33.—*Yields of one variety each of emmer, barley, and oats grown at Hettinger, N. Dak., in 1916 and 1917.*

[Data compiled from North Dakota Agricultural Experiment Station Bulletin 130 (*33*).]

Crop and variety.	C. I. No.	Yields per acre (pounds)		
		1916	1917	Average.
Emmer: Yaroslav	1526	1,980	687	1,334
Barley: Hanna	203	1,940	950	1,445
Oats: Early Mountain	656	2,020	550	1,285

RESULTS AT DICKINSON, N. DAK.

One variety of spring emmer has been grown at the Dickinson, N. Dak., substation since 1907. The experiments have been conducted cooperatively by the Office of Cereal Investigations and the North Dakota Agricultural Experiment Station, and the yields were published in part by Clark (*11*).

The 13-year average acre yield of Yaroslav emmer is 1,476 pounds, as shown in Table 34. During the same period, Hannchen barley yielded 1,435 pounds and Golden Rain oats 1,522 pounds. Considering both yield and feeding value, emmer is about equal to barley and oats at Dickinson, but does not excel them. Its value lies chiefly in permitting a greater diversification of field crops.

TABLE 34.—*Yields of one variety each of emmer, barley, and oats grown at Dickinson, N. Dak., in the 13 years from 1907 to 1921, inclusive, except 1910 and 1912.*[1]

[Data obtained in cooperation with the North Dakota Agricultural Experiment Station.]

Crop and variety.	C. I. No.	Yields per acre (pounds).													
		1907	1908	1909	1911	1913	1914	1915	1916	1917	1918	1919	1920	1921	Average.
Emmer: Yaroslav	1526	1,952	1,180	2,880	1,080	2,150	1,027	3,360	2,072	829	632	166	1,530	326	1,476
Barley: Hannchen	[2] 531	2,247	1,800	2,338	730	1,681	854	3,016	1,911	778	712	91	2,213	279	1,435
Oats: Golden Rain	493	1,126	1,690	2,630	461	2,270	640	4,137	2,138	576	1,584	115	2,166	253	1,522

[1] Emmer crops in 1910 and 1912 destroyed by hail.
[2] Yield of Hanna (C. I. No. 203) substituted in 1907.

RESULTS AT WILLISTON, N. DAK.

The experiments at Williston, N. Dak., have been conducted cooperatively by the Office of Cereal Investigations and the North Dakota Agricultural Experiment Station. Most of the yields of emmer, barley, and oats given in Table 35 were published in 1916 by Babcock (*2*). The average acre yield of Vernal emmer during the 9-year period from 1909 to 1917 was 1,834 pounds. Manchuria barley produced 2,121 pounds and Abundance oats 2,430 pounds per acre during the same period. The yield of emmer thus is distinctly less than that of the other two crops. White Spring spelt was grown in four years and gave an average yield slightly higher than that of Vernal emmer.

TABLE 35.—*Yields of two varieties of emmer and one variety each of spelt, barley, and oats grown at Williston, N. Dak., in the 9-year period from 1909 to 1917, inclusive.*

[Data obtained in cooperation with the North Dakota Agricultural Experiment Station.]

Crop and variety.	C. I. No.	Yields per acre (pounds).										
		1909	1910	1911	1912	1913	1914	1915	1916	1917	Average.	
											1914 to 1917.	1909 to 1917.
Emmer:												
Vernal (White Spring)	1524	.....	.....	.....	.....	.....	.....	3,780	2,780	1,120	.....	.....
Vernal (N. Dak. No. 305)	3701	2,176	452	152	3,180	1,720	1,796	3,360	2,552	.....	[1] 2,207	[1] 1,834
Spelt:												
White Spring	2968	.....	.....	.....	.....	.....	2,824	3,760	1,812	1,040	2,359	.....
Barley:												
Manchuria	643	2,371	322	528	3,432	1,781	3,125	3,582	2,700	1,248	2,664	2,121
Oats:												
Abundance	731	2,914	400	246	3,329	3,018	3,965	3,180	3,301	1,518	2,991	2,430

[1] Vernal emmer (C. I. No. 1524) in 1917.

RESULTS AT EDGELEY, N. DAK.

Two varieties of emmer were grown at the Edgeley, N. Dak., substation from 1904 to 1908. The experiments were conducted cooperatively by the North Dakota Agricultural Experiment Station and the Office of Cereal Investigations. The yields, which have been published by Thompson (*63*), are shown in Table 36. The two lots of Vernal emmer, although apparently identical, produced consider-

ably different yields. The strain C. I. No. 3701, which yielded best, was obtained in North Dakota. A variety of einkorn grown for three years yielded considerably less than the other crops. Manchuria barley produced a higher average yield than emmer, but Swedish Select oats yielded less than emmer at Edgeley in the years grown.

TABLE 36.—*Yields of two varieties of emmer and one variety each of einkorn, barley, and spelt grown at Edgeley, N. Dak., in the four years 1904 to 1906 and 1908.*

[Data obtained in cooperation with the North Dakota Agricultural Experiment Station.]

Crop and variety.	C. I. No.	Yields per acre (pounds).					
						Average.	
		1904	1905	1906	1908	3 years, 1904 to 1906.	4 years, 1904 to 1906, 1908.
Emmer:							
Vernal (White Spring)	3701	2,716	2,896	1,472	564	2,361	1,912
Vernal (Washington)	1524	2,612	2,588	1,284	496	2,161	1,745
Einkorn:							
Common	2433	1,415	1,567	1,735	.....	1,572	.....
Barley:							
Manchuria (Minnesota No. 6)	638	2,395	2,568	1,895	1,046	2,286	1,976
Oats:							
Swedish Select	134	2,535	2,296	1,686	438	2,172	1,739

RESULTS AT LANGDON, N. DAK.

Vernal emmer was grown at the Langdon, N. Dak., substation of the North Dakota Agricultural Experiment Station from 1910 to 1912, inclusive. The yields, as reported by Stewart (*59*) in the reports of the Langdon substation, are shown in Table 37. Vernal emmer yielded more than Mansury (Manchuria) barley, but less than White Russian oats. In feeding value per acre the three crops are about equal. There would seem to be no advantage, therefore, in growing emmer except as it affords greater crop diversification.

TABLE 37.—*Yields of one variety each of emmer, barley, and oats grown at Langdon, N. Dak., in 1910, 1911, and 1912.*

[Data compiled from annual reports of the Langdon substation (*59*).]

Crop and variety.	Yields per acre (pounds).			
	1910	1911	1912	Average.
Emmer: Vernal (White Spring)	776	2,400	1,920	1,699
Barley: Mansury	945	1,945	1,886	1,592
Oats: White Russian	666	2,448	2,350	1,821

RESULTS AT BRANDON, MANITOBA.

Experiments with emmer were begun in 1900 by the Dominion Department of Agriculture on the Brandon Experimental Farm. The data, which have been taken from the annual reports of the Dominion cerealist (*39* and *41*), are shown in Table 38.

Two varieties of emmer and four varieties of spelt were grown during various periods. Of these the Vernal (White Spring) or common

emmer produced the highest average yields and was distinctly superior. Vernal emmer yielded somewhat more grain than Mansury barley, but considerably less than Banner oats. It is not regarded as being equal to these two latter crops.

TABLE 38.— *Yields of two varieties of emmer, four varieties of spelt, and one variety each of barley and oats grown at Brandon, Manitoba, in all or part of the years from 1900 to 1908, inclusive.*

[Data compiled from reports of the Dominion Experimental Farms (*39* and *41*).]

Crop and variety.	Yields per acre (pounds).										
	1900	1901	1902	1903	1904	1905	1906	1907	1908	Average. 1904 to 1907.	Average. 1900 to 1908.
Emmer:											
Vernal (White Spring)	2,740	2,720	2,080	2,630	4,140	2,840	3,820	2,820	2,210	3,405	2,889
Red	.....	.....	.....	2,320	2,780	2,500	3,000	1,930	.....	2,552	.....
Spelt:											
Smooth	.....	.....	.....	1,760	.....	.....	.....	.....	.....	.....	.....
White Bearded	.....	.....	.....	1,620	.....	.....	.....	.....	.....	.....	.....
Red	.....	.....	.....	.....	2,000	3,500	3,180	1,940	.....	2,655	.....
White Spring	.....	.....	.....	.....	1,240	2,280	2,740	1,720	.....	1,995	.....
Barley:											
Mansury	1,960	2,320	2,020	3,450	2,260	3,630	2,950	2,950	2,870	2,948	2,712
Oats:											
Banner	970	2,900	2,400	2,860	4,460	4,160	3,880	4,350	3,880	4,213	3,318

RESULTS AT INDIAN HEAD, SASKATCHEWAN.

Two varieties of emmer and three varieties of spelt were grown at Indian Head Agricultural Experimental Farm by the Dominion Department of Agriculture during varying periods from 1900 to 1907. The results, taken from the annual reports of the Dominion cerealist (*39* and *41*), are shown in Table 39.

Vernal (White Spring or Common) emmer produced the highest average yield, followed by Red spelt. During the entire eight years, Vernal emmer produced less than Odessa barley and much less than Banner oats. Both barley and oats are far more successful at Indian Head than any variety of emmer or spelt.

TABLE 39.— *Yields of two varieties of emmer, three varieties of spelt, and one variety each of barley and oats grown at Indian Head, Saskatchewan, in the 8-year period from 1900 to 1907, inclusive.*

[Data compiled from reports of the Dominion Experimental Farms (*39* and *41*).]

Crop and variety.	Yields per acre (pounds).									
	1900	1901	1902	1903	1904	1905	1906	1907	Average. 1904 to 1907.	Average. 1900 to 1907.
Emmer:										
Vernal (White Spring)	1,320	3,500	2,180	3,280	3,100	2,940	3,220	2,020	2,820	2,695
Red	.....	.....	.....	2,730	1,520	3,040	2,980	1,320	2,215	.....
Spelt:										
White Spring	.....	.....	.....	2,380	1,720	3,340	3,160	1,560	2,445	.....
Black Bearded	.....	.....	.....	1,590	.....	.....	.....	.....	.....	.....
Red	.....	.....	.....	.....	1,120	3,420	3,600	2,200	2,585	.....
Barley:										
Odessa	2,640	3,300	3,120	3,420	3,000	2,980	3,160	2,000	2,785	2,953
Oats:										
Banner	2,040	4,400	3,000	4,650	4,210	3,240	4,380	4,180	4,003	3,763

RESULTS AT ROSTHERN, SASKATCHEWAN.

Experiments with emmer at the Rosthern Experimental Farm have been recorded in the annual report of the Dominion Experimental Farms for 1915 (*39*).

In that year Vernal emmer produced only 2,680 pounds per acre in comparison with 3,980 pounds of barley and 3,645 pounds of oats. Emmer is not well adapted to the conditions at Rosthern.

RESULTS AT LETHBRIDGE, ALBERTA.

Yields of emmer on nonirrigated land at the Lethbridge Experimental Farm have been reported for three years in the annual reports of the Dominion Experimental Farms (*39*). Buffum Black Winter emmer was able to survive one winter, but yielded only 1,080 pounds per acre. Vernal emmer produced an average yield of only 1,643 pounds per acre, in comparison with 2,247 pounds of Swedish Chevalier barley and 2,487 pounds of Banner oats. The annual yields are shown in Table 40.

TABLE 40.—*Yields of two varieties of emmer and one variety each of spelt, barley, and oats grown on nonirrigated land at Lethbridge, Alberta, in 1908, 1909, and 1912.*

[Data compiled from reports of the Dominion Experimental Farms (*39*).]

Crop and variety.	Yields per acre (pounds).			
	1908	1909	1912	Average.
Emmer:				
Buffum Black Winter			1,080	
Vernal (White Spring)	2,230	1,380	1,320	1,643
Spelt:				
Red	2,230			
Barley:				
Swedish Chevalier	2,100	2,660	1,980	2,247
Oats:				
Banner	2,900	1,920	2,640	2,487

RESULTS AT LACOMBE, ALBERTA.

Yields of two varieties each of emmer and spelt grown at Lacombe, Alberta, have been published in the reports of the Dominion Experimental Farms (*39*). These are shown in Table 41. Red spelt produced a 4-year average yield of 2,445 pounds per acre, or about 30 per cent more than Vernal emmer. Mansfield barley and Banner oats both yielded considerably more than any of the varieties of emmer and spelt.

TABLE 41.—*Yields of two varieties each of emmer and spelt and one variety each of barley and oats grown at Lacombe, Alberta, in the 4-year period from 1907 to 1910, inclusive.*

[Data compiled from reports of the Dominion Experimental Farms (*39*).]

Crop and variety.	Yields per acre (pounds).				
	1907	1908	1909	1910	Average.
Emmer:					
Vernal (White Spring)	1,200	2,400	1,140	2,700	1,860
Red	540				
Spelt:					
Red	1,020	3,180	1,560	4,020	2,445
White	840				
Barley:					
Mansfield	3,300	3,000	1,380	3,030	2,678
Oats:					
Banner	3,150	3,030	1,570	2,670	2,613

RESULTS IN THE WESTERN BASIN AND COAST AREA.

The cultivated land in the area lying west of the Rocky Mountains is located mostly in elevated basins and plateaus and in the interior and coastal valleys. The altitude of the farming lands in these sections varies from slightly above sea level to more than 8,000 feet. The annual precipitation ranges from less than 5 inches in southern Arizona to more than 100 inches in districts along the coast of Washington and Oregon.

There is a wide variety of soils and cropping conditions. The principal cereal-producing sections are the Palouse section of Washington and Idaho, the Columbia Basin of Washington and Oregon, and the Sacramento and San Joaquin Valleys of California. A considerable acreage of grain is grown also in southern Idaho, northern Utah, and in the humid valleys of California and Oregon.

Experiments with emmer and spelt have been conducted cooperatively by the Office of Cereal Investigations at seven stations in the Western Basin and Pacific Coast area. In addition to these, the published results from six other stations are here included. Most of the data are for rather short periods, but this is due to the fact that, in general, emmer and spelt have been rather unpromising.

RESULTS AT COCHISE, ARIZ.

Yields of emmer and spelt obtained at the Sulphur Springs Valley Dry Farm near Cochise, Ariz., were reported by McOmie and others (*29*) in Bulletin 84 of the Arizona Agricultural Experiment Station. In 1914 the crops were irrigated, but the yields obtained were very small, due to damage by rabbits. Only 111 pounds of Black Winter emmer and 150 pounds of Red Winter spelt per acre were harvested. Yields of barley and oats as well as emmer and spelt were obtained in 1915 on dry land. Spelt produced 633 pounds, emmer 572 pounds, six-rowed barley 969 pounds, and Red Rustproof (Red Texas) oats 296 pounds. An additional plat of Red Winter spelt which was sown early yielded considerably more than barley.

RESULTS AT PHOENIX, ARIZ.

Yields of one variety each of emmer and spelt at Phoenix, Ariz., grown in the season of 1915 were reported by McOmie (*28*, p. 520) in the annual report of the Arizona Agricultural Experiment Station for that year. The yields obtained on irrigated land are as follows: Black Winter emmer, 3,630 pounds; Red Winter spelt, 2,970 pounds; Red Rustproof oats, 2,970 pounds; and Utah winter barley, 3,685 pounds. Barley is usually the most productive of the small grains for feed in southern Arizona.

RESULTS AT PRESCOTT, ARIZ.

Experiments with emmer, spelt, barley, and oats resulted in almost complete failures at the Prescott, Ariz., Dry Farm, due to winter-killing, drought, and rodent damage. The small yields of spelt, oats, and barley obtained, as reported by McOmie and others (*29*), are shown in Table 42. Red Winter spelt produced a higher average yield than Utah Winter barley and Black oats, but all yields were very low. During the same two years Turkey winter wheat, the yields of which are not shown in the table, produced more than twice as much as the Red Winter spelt. Wheat was much more productive than the other small-grain crops at Prescott.

TABLE 42.— *Yields of one variety each of spelt, barley, and oats grown on the Prescott, Ariz., Dry Farm in 1914 and 1915.*

[Data compiled from Arizona Experiment Station Bulletin 84 (29).]

Crop and variety.	Yields per acre (pounds).		
	1914	1915	Average.
Spelt: Red Winter (C. I. No. 1772)	80	342	211
Barley: Utah Winter	40	200	120
Oats: Black	8	0	4

RESULTS AT SNOWFLAKE, ARIZ.

A yield of 560 pounds per acre of Black Winter emmer was obtained at the Snowflake, Ariz., Dry Farm in 1915. Black (Snowflake) oats produced an acre yield of 768 pounds in the same season. The barley which was sown was destroyed by smut. The yields are reported by McOmie and others (*29*).

RESULTS AT PASO ROBLES, CALIF.

In 1893, two varieties of emmer and four varieties of spelt were grown in experiments at Paso Robles, Calif. The yields, which were published by Shinn (*50*, p. 396) in the report of the agricultural experiment station of the University of California for that year, were as follows: Red emmer, 1,475 pounds; White emmer, 2,098 pounds; White Silesian spelt, 2,893 pounds; Blue Bearded spelt, 2,036 pounds; White Bearded spelt, 2,609 pounds; Bearded Brown spelt, 1,134 pounds; Dept. Agr. No. 2 barley, 3,970 pounds; and White Wonder oats, 2,495 pounds. Two of the varieties of spelt outyielded the White Wonder oats, but were decidedly inferior to the barley. Emmer was less productive than the better varieties of spelt.

RESULTS AT MODESTO, CALIF.

The results of experiments covering three years with emmer and spelt at Modesto, Calif., are shown in Table 43. The experiments were conducted by the Office of Cereal Investigations in cooperation with the California Agricultural Experiment Station. The average yields of all crops were rather low. Red Winter spelt produced more than Black Winter emmer and White Smyrna barley but less than Appler oats. The experiments were not conducted for a sufficient period to be conclusive, and the varieties of barley and oats with which they were compared are not the most productive ones in California. These and other results do not show emmer and spelt to be promising in that State.

TABLE 43.— *Yields of one variety each of emmer, spelt, barley, and oats grown at Modesto, Calif., in 1906, 1908, and 1909.*

[Data obtained in cooperation with the California Agricultural Experiment Station.]

Crop and variety.	C. I. No.	Yields per acre (pounds).			
		1906	1908	1909	Average.
Emmer: Black Winter	2,337	390	0	1,058	483
Spelt: Red Winter	1,772	100	0	2,060	720
Barley: White Smyrna	195	523	518	653	565
Oats: Appler	339	670	1,693	282	882

RESULTS AT CHICO, CALIF.

The experiments at the Plant Introduction Garden, Chico, Calif., were conducted by the Office of Cereal Investigations in cooperation with the Office of Foreign Seed and Plant Introduction, of the Bureau of Plant Industry. Emmer and spelt were grown three years at that station, as shown in Table 44. Black Winter emmer yielded more than Sixty-Day oats but less than Coast barley. The two selections of emmer from Abyssinia yielded less than the Black Winter variety. Red Winter spelt yielded during two years nearly as well as the barley. Neither emmer nor spelt is as productive as barley in California.

TABLE 44.—*Yields of three varieties of emmer and one variety each of spelt, barley, and oats grown at Chico, Calif., in 1911, 1913, and 1914.*

[Data obtained in cooperation with the Office of Foreign Seed and Plant Introduction.]

Crop and variety.	C.I.No.	Yields per acre (pounds).					
		1911	1913	1914	Average. 1911, 1913, and 1914.	Average. 1911 and 1914.	Average. 1911 and 1913.
Emmer:							
Black Winter	2337	3,480	1,625	1,070	2,058	2,275	2,553
Abyssinian Selection	2510–1	1,960	.....	1,000	.....	1,480	.....
Do	2510–2	2,120	.....	910	.....	1,515	.....
Spelt:							
Red Winter	1772	3,520	1,900	.....	.....	.....	2, 10
Barley:							
Coast	690	3,182	2,275	2,305	2,587	2,744	2,729
Oats:							
Sixty-Day	165	1,673	1,385	1,254	1,437	1,464	1,529

RESULTS AT NEPHI, UTAH.

Experiments with emmer were begun at the Nephi, Utah, substation in 1908 and were conducted cooperatively by the Office of Cereal Investigations and the Utah Agricultural Experiment Station until 1920. The results, which have been published in part by Cardon (*6*), are shown in Table 45. Black Winter emmer has outyielded both barley and oats at Nephi, but Red Winter spelt has produced still higher yields. Buffum Black Winter emmer was grown for five years and appeared to be identical with the ordinary Black Winter variety. The slight differences in yield between the two varieties are not considered as being significant. Winter wheat is the leading small-grain crop at Nephi and has produced considerably higher yields than either emmer or spelt.

TABLE 45.— *Yields of three varieties of emmer and one variety each of spelt, barley, and oats grown at Nephi, Utah, in all or part of the 13 years from 1908 to 1920, inclusive.*

[Data obtained in cooperation with the Utah Agricultural Experiment Station.]

Crop and variety.	C. I. No.	Yields per acre (pounds).						
		1908	1909	1910	1911	1912	1913	1914
Emmer:								
Black Winter	2337	1,322	1,373	1,024	1,834	816	160	1,958
Buffum Black Winter	3331	.....	.....	.....	.....	806	301	2,410
Vernal (White Spring)	1524	.....	.....	.....	.....	.....	.....	.....
Spelt:								
Red Winter	1772	.....	.....	.....	.....	.....	.....	.....
Barley:								
Tennessee Winter	257	.....	.....	792	1,180	197	48	2,443
Oats:								
Swedish Select	134	1,408	490	198	282	179	419	982

TABLE 45.—*Yields of three varieties of emmer and one variety each of spelt, barley, and oats grown at Nephi, Utah, in all or part of the 13 years from 1908 to 1920, inclusive*—Continued.

Crop and variety.	C. I. No.	Yields per acre (pounds).							
		1915	1916	1917	1918	1919	1920	Average. 1915 to 1920.	Average. 1910 to 1920.
Emmer:									
Black Winter	2337	[1] 1,501	522	1,235	1,222	579	1,312	1,062	1,106
Buffum Black Winter	3331	1,511	487	.....	.....	.....	.....	.....	.....
Vernal (White Spring)	1524	.....	538	390	960	.....	.....	.....	.....
Spelt:									
Red Winter	1772	2,282	832	1,600	1,229	848	1,411	1,367	.....
Barley:									
Tennessee Winter	257	2,088	381	1,042	1,248	653	802	1,036	989
Oats:									
Swedish Select	134	1,252	506	275	740	141	541	576	501

[1] Yield from nursery row.

RESULTS AT ABERDEEN, IDAHO.

Two varieties of winter emmer were grown at the Aberdeen, Idaho, substation on dry land during 1913 and 1914. The experiments were conducted by the Office of Cereal Investigations in cooperation with the Idaho Agricultural Experiment Station. Both White Smyrna barley and Sixty-Day oats sown in the spring yielded nearly twice as much as the winter emmer. The yields are shown in Table 46.

TABLE 46.—*Yields of two varieties of emmer and one variety each of barley and oats grown on dry land at Aberdeen, Idaho, in 1913 and 1914.*

[Data obtained in cooperation with the Idaho Agricultural Experiment Station.]

Crop and variety.	C. I. No.	Yields per acre (pounds).		
		1913	1914	Average.
Emmer:				
Black Winter	2337	659	915	787
Buffum Black Winter	3331	486	822	654
Barley:				
White Smyrna	195	1,459	1,698	1,579
Oats:				
Sixty-Day	165	1,520	1,290	1,405

RESULTS AT BURNS, OREG.

Emmer and spelt were grown at the Harney County branch station, Burns, Oreg., from 1913 to 1916. The experiments were conducted cooperatively by the Office of Cereal Investigations and the Oregon Agricultural Experiment Station. The results, which have been published by Scudder (*45*) and Breithaupt (*4*), are shown in Table 47. Vernal (White Spring) emmer yielded considerably more than the Black Winter variety. In two years Red Winter spelt produced slightly more than the Vernal emmer. Hannchen barley and a pure-line selection from an oat known as Rustless (probably Green Russian) both yielded about twice as much as Vernal emmer in the 4-year period.

TABLE 47.—*Yields of four varieties of emmer and one variety each of spelt, barley, and oats grown at Burns, Oreg., in the 4-year period from 1913 to 1916, inclusive.*

[Data obtained in cooperation with the Oregon Agricultural Experiment Station.]

Crop and variety.	C. I. No.	Yields per acre (pounds).					
		1913	1914	1915	1916	Average. 1915 and 1916.	Average. 1913 to 1916.
Emmer:							
Black Winter	2,337	688	.....	.....	.....	.....	.....
Do	2,483	896	86	560	64	312	402
Vernal (White Spring)	1,524	1,200	138	522	736	629	649
Yaroslav	1,526	.....	.....	480	.....	.....	.....
Spelt:							
Red Winter	1,772	.....	.....	980	320	650	.....
Barley:							
Hannchen	531	2,000	638	442	2,390	1,416	1,368
Oats:							
Rustless Selection	724	1,798	358	1,580	1,440	1,510	1,294

RESULTS AT MORO, OREG.

Both emmer and spelt have been grown at the Sherman County branch station, Moro, Oreg. The experiments were conducted cooperatively by the Office of Cereal Investigations and the Oregon Agricultural Experiment Station. The yields have been published in part by Scudder (*45*), Stephens (*56*, *57*), and Stephens and Hill (*58*). The results here considered are presented in Table 48.

Black Winter emmer produced higher average yields than Vernal (White Spring) emmer. Red Winter spelt yielded much more than any of the emmer varieties and even exceeded Kherson oats. Marioout barley, however, is far more productive than the spelt or any of the emmer varieties and is the most promising small-grain feed crop. Winter wheat is the most productive grain crop at Moro and has produced considerably higher net yields than spelt.

TABLE 48.—*Yields of five varieties of emmer and one variety each of spelt, barley, and oats grown at Moro, Oreg., in all or part of the nine years from 1912 to 1920, inclusive.*

[Data obtained in cooperation with the Oregon Agricultural Experiment Station.]

Crop and variety.	C. I. No.	Yields per acre (pounds).										
		1912	1913	1914	1915	1916	1917	1918	1919	1920	Average. 1914 to 1918.	Average. 1912 to 1919.
Emmer:												
Black Winter	2337	1,225	765	970	858	998	410	1,549	1,280	.....	957	1,007
Brown Winter	.....	.....	.....	.....	.....	.....	461	1,629	1,298	.....	.....	.....
Vernal (White Spring)	1524	1,008	800	816	579	1,184	682	419	.....	.....	736	.....
Yaroslav	1526	.....	.....	.....	832	1,280	1,021	630	.....	.....	.....	.....
Khapli	4013	.....	.....	.....	.....	.....	.....	.....	.....	648	.....	.....
Spelt:												
Red Winter	1772	.....	.....	1,593	1,488	2,500	941	2,269	2,400	928	1,758	.....
Barley:												
Mariout	261	1,344	1,948	2,020	2,610	3,325	2,180	1,392	1,930	1,832	2,305	2,094
Oats:												
Kherson	459	.....	1,395	1,735	1,683	2,700	1,200	1,072	1,821	1,168	1,678	.....

RESULTS AT LIND, WASH.

Emmer and spelt were grown at the Adams branch experiment station, Lind, Wash. in 1918 and 1919. The experiments were conducted cooperatively by the Office of Cereal Investigations and the Washington Agricultural Experiment Station. The yields of all grains shown in Table 49 are very low on account of drought. Both Black Winter and Vernal (White Spring) emmer produced poor yields. Red Winter spelt outyielded oats and produced about the same yield as barley. Wheat is the most productive grain crop at Lind, and in 1918 and 1919 it produced a higher average yield than spelt.

TABLE 49.— *Yields of two varieties of emmer and one variety each of spelt, barley, and oats grown at Lind, Wash., in 1918 and 1919.*

[Data obtained in cooperation with the Washington Agricultural Experiment Station.]

Crop and variety.	C. I. No.	Yields per acre (pounds).		
		1918	1919	Average.
Emmer:				
Buffum Black Winter	3,331	250	480	365
Vernal (White Spring)	1,552	170	.....	.....
Spelt:				
Red Winter	1,772	370	838	604
Barley:				
California	1,279	307	893	600
Oats:				
Richland	787	280	736	508

RESULTS AT AGASSIZ, BRITISH COLUMBIA.

Experiments with emmer and spelt under humid conditions were conducted at Agassiz, British Columbia, in the five years from 1901 to 1905 by the Dominion Department of Agriculture. The yields as presented in the reports of the Dominion cerealist (*39* and *41*) are shown in Table 50. Vernal emmer yielded more than any of the other varieties of emmer or of spelt, but was markedly exceeded by Mansury (Manchuria) barley and somewhat outyielded by Lincoln oats.

TABLE 50.— *Yields of five varieties of emmer, two varieties of spelt, and one variety each of barley and oats grown at Agassiz, British Columbia, in the 5-year period from 1901 to 1905, inclusive.*

[Data compiled from reports of Dominion Experimental Farms (*39* and *41*).]

Crop and variety.	C.I.No.	Yields per acre (pounds).						
		1901	1902	1903	1904	1905	Average.	
							1903 to 1905.	1901 to 1905.
Emmer:								
Vernal (White Spring)	.....	2,370	2,220	2,190	1,920	1,840	1,983	2,108
Do	2,975	.....	.....	2,130	1,470	.....	.....	.....
Vernal (S. Dak. No. 524)	.....	.....	.....	2,040	1,660	.....	.....	.....
Thick	.....	.....	.....	1,920	.....	.....	.....	.....
Red	.....	.....	.....	.....	1,840	1,480	.....	.....
Spelt:								
Red	.....	.....	.....	1,960	1,680	1,510	1,717	.....
White Bearded	.....	.....	.....	1,720	1,590	.....	.....	.....
White Spring	.....	.....	.....	.....	.....	1,960	.....	.....
Barley:								
Mansury	2,657	2,860	1,860	3,840	3,000	2,570	3,137	2,826
Oats:								
Lincoln	.....	3,220	2,360	2,100	1,960	2,160	2,073	2,360

CULTURAL EXPERIMENTS.

Owing to the relative unimportance of emmer and spelt in most sections, these crops usually have not been included in cultural, tillage, and rotation experiments. The results of a few experiments conducted at various stations to determine the best rates, dates, depths, and methods of seeding emmer are presented on the following pages.

RATE-OF-SEEDING EXPERIMENTS.

RESULTS WITH WINTER EMMER.

Results of experiments on rates of seeding with Black Winter (C. I. 2337) emmer covering from one to three years have been obtained at Amarillo, Tex., Nephi, Utah, and Archer, Wyo., in cooperative experiments of the Office of Cereal Investigations. The results obtained are shown in Table 51. The highest average yields were from the plats sown at the rate of 6 pecks per acre, but the 5-peck sowing produced the highest net yields at Amarillo.

It usually is difficult to obtain a good stand of Black Winter emmer The spikelets are so large that they feed through the grain drill only with difficulty. With the drill adjusted as for sowing oats, emmer will be sown at nearly the same rate as oats. From the results at the three stations it appears that Black Winter emmer should be sown at the rate of about 6 pecks per acre.

TABLE 51.—*Yields of Black Winter emmer in rate-of-seeding experiments at Amarillo, Tex., Nephi, Utah, and Archer, Wyo., during one or more years from 1912 to 1916, inclusive.*

Station and rate of seeding.	Yields per acre (pounds).					
	1912	1913	1914	1915	1916	Average.
Amarillo, Tex.:						
4 pecks	.....	350	.....	630	215	398
5 pecks	.....	313	.....	760	220	431
6 pecks	.....	320	.....	730	250	433
8 pecks	.....	330	.....	605	325	420
Nephi, Utah:						
4 pecks	.....	.....	.....	.....	381	.....
5 pecks	362	.....	1,820	.....	522	901
6 pecks	432	.....	1,940	.....	630	1,001
7 pecks	368	.....	2,070	.....	461	966
8 pecks	272	.....	2,110	.....	640	1,007
Archer, Wyo.:						
4 pecks	.....	.....	.....	173	.....	.....
5 pecks	.....	.....	.....	259	.....	.....
6 pecks	.....	.....	.....	269	.....	.....

RESULTS WITH SPRING EMMER.

The results of rate-of-seeding experiments with Vernal (White Spring) emmer, conducted at four stations in the United States and one station in Canada, are shown in Table 52. At Manhattan, Kans., during one season, a sowing of 84 pounds per acre produced the highest yield, but the sowing of 56 pounds returned almost the same net yield. At North Platte, Nebr., and Eureka, S. Dak., the seeding of 6 pecks per acre produced the highest yields. At Archer, Wyo., the 3-peck seeding was the most productive, but the difference in

yield between the 3, 4, and 5 peck rates is small. At Brandon, Manitoba, higher rates of seeding produced the most favorable results, the highest yield being obtained from the 7-peck sowing the first year and from the 87½-pound rate the second year of the trial. From these results it appears that Vernal emmer should be sown at about 6 pecks per acre in the drier Great Plains area and at a somewhat higher rate in the subhumid prairie section. In practice, the emmer should be sown at about the same rate as oats in a given locality.

TABLE 52.—*Yields of Vernal emmer in rate-of-seeding experiments at stations named in Kansas, Nebraska, Wyoming, South Dakota, and Manitoba during one or more years from 1901 to 1919, inclusive.*

Station and rate of seeding.	Yields per acre (pounds).							
	1901	1902	1906	1907	1908	1909	1912	1913
Manhattan, Kans.:								
56 pounds			1,472					
70 pounds			1,449					
75 pounds			1,485					
84 pounds			1,503					
89 pounds			1,431					
North Platte, Nebr.:								
2 pecks			748	1,004	1,772	1,368	408	
4 pecks			920	1,432	2,032	1,344	428	
6 pecks			1,112	1,816	2,104	1,464	700	
8 pecks			940	1,716	2,100	1,328	828	
Eureka, S. Dak.:								
4 pecks							19	131
5 pecks							70	
6 pecks							38	150
8 pecks								330
Brandon, Manitoba:								
4 pecks	1,998							
5 pecks	2,268							
7 pecks	2,760							
50 pounds		2,538						
62½ pounds		2,802						
75 pounds		3,138						
87½ pounds		3,282						
100 pounds		3,018						

Station and rate of seeding.	Yields per acre (pounds).								
	1914	1915	1916	1917	1918	1919	Average.		
							4 years.	5 years.	7 years.
North Platte, Nebr.:									
2 pecks								1,060	
4 pecks								1,231	
6 pecks								1,439	
8 pecks								1,382	
Archer, Wyo.:									
2 pecks			419	845	1,545	211	755		
3 pecks		864	419	1,175	1,690	202	872	870	
4 pecks		864	346	1,175	1,600	289	848	851	
5 pecks		912	378	1,172	1,535	240	831	847	
6 pecks			368	1,082	1,495	234	795		
7 pecks						208			
Eureka, S. Dak.:									
4 pecks	1,091	2,450	1,638	461	64	800			948
5 pecks									
6 pecks	1,021	2,620	1,741	429	122	681			966
8 pecks	970	2,000	1,350	608	32	941			890

DATE-OF-SEEDING EXPERIMENTS.

RESULTS WITH WINTER EMMER.

Date-of-seeding experiments with Black Winter (C. I. No. 2337) emmer have been conducted at Amarillo, Tex., and Nephi, Utah. The results obtained are shown in Table 53. At Amarillo, which is located in the Panhandle section of Texas, the average yields for five years were practically the same from the second sowing made between October 14 and October 19 and the third sowing made between November 1 and November 7. These yields were but little higher than those from the first sowing made between September 1 and October 5. Four-year results show a slight advantage for the first sowing. At Nephi, Utah, which is about 300 miles farther north than Amarillo and at an altitude of nearly 6,000 feet, the average yield was slightly higher from the sowings made on October 1 than from those made earlier or later. In general, winter emmer should be sown at about the same time as winter wheat.

TABLE 53.—*Yields of Black Winter emmer in date-of-seeding experiments at Amarillo, Tex., and Nephi, Utah, during the 5-year period from 1911 to 1916, inclusive.*

Station and date of seeding.	Yields per acre (pounds).							
						Average.		
	1911	1912	1913	1914	1916	3 years.	4 years (1912, 1913, 1914, and 1916).	5 years.
Amarillo, Tex.:								
Sept. 1 to Oct. 5	130	75	780	440	220	.....	379	329
Oct. 14 to Oct. 19	580	80	510	580	180	.....	338	386
Nov. 1 to Nov. 7	860	132	280	480	170	.....	266	384
Nov. 15 to Nov. 16	.....	90	300	550	150	.....	273	.....
Nephi, Utah:								
Aug. 15	.....	.....	.....	970	.....	.....	.....	.....
Sept. 1 to Sept. 7	.....	832	179	1,430	.....	814	.....	.....
Sept. 15	.....	704	330	1,530	.....	855	.....	.....
Oct. 1	.....	903	320	1,760	.....	994	.....	.....
Oct. 15	.....	672	410	1,760	.....	947	.....	.....
Nov. 1	.....	.....	.....	1,520	.....	.....	.....	.....

RESULTS WITH SPRING EMMER.

The yields obtained in date-of-seeding experiments with Vernal (White Spring) emmer at North Platte, Nebr., Highmore, S. Dak., and Brandon, Manitoba, are shown in Table 54. The data from North Platte are taken from Bulletin No. 172 of the Nebraska Agricultural Experiment Station (*73*). Most of the yields from Highmore were published in Bulletin 179 of the South Dakota Agricultural Experiment Station (*10*) and those from Brandon, Manitoba, in the annual report of the Dominion experimentalist for 1902 (*41*).

At North Platte and Highmore the earliest sowings produced the highest average yields, although later sowings are ahead in some years at North Platte. Similar results have been obtained with the other spring grains at those stations. At Brandon, Manitoba, the results are for one year only and therefore are not conclusive. The latest seeding, on May 27, produced the highest yield, and the earliest seeding, on May 6, the second highest yield.

TABLE 54.—*Yields of Vernal emmer in date-of-seeding experiments at North Platte, Nebr., Highmore, S. Dak., and Brandon, Manitoba, during one or more years from 1902 to 1918.*

Station and date of seeding.	Yields per acre (pounds).													
	1902	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	Average. 3 years.	Average. 4 years.	Average. 10 years.
North Platte, Nebr.:[1]														
Mar. 25	.....	1,524	828	0	[2]440	192	28	[2]1,812	922	420	176	.....	.....	636
Apr. 6	.....	[3]1,601	312	0	440	40	64	1,812	452	136	208	.....	.....	507
Apr. 18	.....	1,660	152	0	284	32	240	1,060	132	68	28	.....	.....	366
Apr. 30	.....	1,324	[4]152	....	....	....	236	1,268	80	44	....	.....	.....	.....
Highmore, S. Dak.:														
Mar. 16	.....	.....	.....	.....	.....	.....	.....	.....	2,300	.....	.....	.....	.....	.....
Apr. 1 to 12	.....	.....	.....	.....	.....	.....	2,495	3,600	1,797	1,337	....	2,631	2,307	.....
Apr. 15 to 22	.....	.....	.....	.....	.....	.....	1,801	3,600	1,848	.....	....	2,416	.....	.....
May 1 to 7	.....	.....	.....	.....	.....	.....	1,852	2,640	800	1,075	....	1,764	1,592	.....
May 15	.....	.....	.....	.....	.....	.....	.....	.....	.....	826	....	.....	.....	.....
Brandon, Manitoba:														
May 6	3,540	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
May 13	3,120	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
May 20	3,375	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
May 27	3,660	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

[1] Dates shown are average dates of first, second, third, and fourth seedings, respectively.
[2] Yields from first seeding used for both first and second dates.
[3] Yield supplied by using average of first and third dates.
[4] Yield supplied by using that of third date.

In other experiments at the Ontario Agricultural College, Guelph, Ontario, Vernal (White Spring) emmer and Red spelt were sown on eight dates each spring during a 5-year period. The first sowings were made at the earliest possible date each year and later sowings each succeeding week thereafter. The average data for five years are shown in Table 55. The results show that the highest average yields of emmer were obtained from the second sowing, but that only slight differences exist between the results from the first four sowings. The later sowings, however, yielded progressively less. The earliest sowing of Red spelt produced the highest yield, with marked decreases from all later sowings. As mentioned in the description of Red spelt, this variety usually is grown as a winter crop in the United States. It will mature seed from spring sowing and, if sown early, as here shown, will produce good yields. Its late maturity, together with the winter or intermediate habit of growth, make it an unsatisfactory spring crop in most sections.

TABLE 55.—*Yields of Vernal emmer and Red spelt in date-of-seeding experiments at Guelph, Ontario, during a 5-year period.*

[Data compiled from Ontario Agricultural College Bulletin 268 (71).]

Periods of seeding.	Yields per acre (pounds). Vernal emmer.	Yields per acre (pounds). Red spelt.	Periods of seeding.	Yields per acre (pounds). Vernal emmer.	Yields per acre (pounds). Red spelt.
First	2,747	2,377	Fifth	2,569	1,287
Second	2,848	2,163	Sixth	2,465	933
Third	2,646	1,898	Seventh	2,312	685
Fourth	2,754	1,582	Eighth	1,953	499

DEPTH-OF-SEEDING EXPERIMENTS.

Depth-of-seeding experiments with Black Winter (C. I. 2337) emmer were conducted at the Nephi substation, Nephi, Utah, in 1914 and 1915. The yields, as shown in Table 56, are about the same for 1½-inch and 3-inch seedings, although averaging slightly higher for the shallower seeding.

TABLE 56.— *Yields of Black Winter emmer in depth-of-seeding experiments at Nephi, Utah, in 1914 and 1915.*

Depth of seeding.	Yields per acre (pounds).		
	1914	1915	Average.
1½ inches	1,722	1,652	1,687
3 inches	1,680	1,660	1,670
6 inches	1,548	1,261	1,405

METHOD-OF-SEEDING EXPERIMENTS.

Vernal (White Spring) emmer was sown both broadcast and in drills during several seasons at the North Platte substation, North Platte, Nebr. The yields, which were reported in Bulletin No. 135 of the Nebraska Agricultural Experiment Station (*54*), are shown in Table 57. The drilled emmer produced an average of 1,400 pounds of grain per acre in comparison with 1,043 pounds per acre when sown broadcast.

TABLE 57.— *Yields of Vernal emmer in method-of-seeding experiments, at North Platte, Nebr., in four years from 1908 to 1912 (1911 omitted).*

[Data compiled from Nebraska Agricultural Experiment Station Bulletin 135 (*54*).]

Method of seeding.	Yields per acre (pounds).				
	1908	1909	1910	1912	Average.
Broadcast	1,848	880	688	756	1,043
Drilled	2,104	1,624	984	888	1,400

SUMMARY.

Emmer has been grown to a considerable extent in the United States during the past 25 years, and spelt has been grown on small acreages. Einkorn is not grown commercially in this country. Emmer, spelt, and einkorn are species of wheat the kernels of which remain inclosed in the glumes after threshing. As ordinarily threshed the grain weighs about 32 pounds to the bushel.

Emmer and einkorn have been known since prehistoric times, and spelt has been grown for more than 200 years.

Emmer and spelt are grown principally in Russia, Germany, and the United States. Most of the crop reported in this country consists of emmer. South Dakota, North Dakota, and Nebraska are the three leading States in the production of emmer.

Emmer, as threshed with the kernels remaining in the glumes, has a composition similar to that of oats and a feeding value somewhat lower than that of barley.

The kernels freed from the inclosing glumes are similar to wheat, but flour made from them is of inferior quality for bread making.

Several varieties of emmer, spelt, and einkorn have been grown in experiments in the United States and Canada, but as far as known only five varieties, Vernal (White Spring), Khapli, and Black Winter emmer, and Alstroum and Red Winter spelt, are grown commercially. Vernal and Khapli emmer are very resistant to rust.

TABLE 58.—*Yields of winter and spring emmer, spelt, and the leading variety of barley and oats grown at each of 52 experiment stations in the United States and Canada during the number of years indicated.*

Area and station.	Number of years grown.	Average yields per acre (pounds).				
		Emmer (winter).	Emmer (spring).	Spelt (winter).	Barley (spring).	Oats (spring).
South Atlantic (humid) area:						
Athens, Ga.	5	774	.....	1,108	[1] 2,188	[1] 1,185
Arlington Farm, Va.	11	641	.....	2,209	1,434	[1] 1,586
College Park, Md.	6	1,097	.....	1,897	[1] 1,548	[1] 1,577
Mississippi and St. Lawrence Valleys (subhumid) area:						
Denton, Tex.	3	888	.....	1,080	[1] 1,538	[1] 1,354
McPherson, Kans.	5	1,137	.....	1,103	1,222	1,177
Manhattan, Kans.	7	.....	1,227	.....	1,666	1,432
La Fayette, Ind.	5	.....	1,053	.....	1,130	1,478
Madison, Wis.	3	.....	1,140	.....	2,437	1,594
St. Paul, Minn.	3	.....	1,595	.....	1,447	1,616
Morris, Minn.	3	.....	1,611	.....	1,771	1,560
Grand Rapids, Minn.	3	.....	1,050	.....	1,378	1,350
Crookston, Minn.	7	.....	1,403	.....	1,643	1,636
Brookings, S. Dak.	12	.....	1,818	.....	2,170	2,048
Fargo, N. Dak.	14	.....	2,109	.....	2,010	1,911
Guelph, Ontario	18	.....	2,548	.....	2,673	2,591
Ottawa, Ontario	10	.....	2,090	[2] 2,088	2,496	2,366
Nappan, Nova Scotia	7	.....	1,911	[2] 1,997	2,243	2,246
Great Plains (semiarid) area:						
Amarillo, Tex.	13	418	.....	461	[1] 660	622
Channing, Tex.	2	1,029	.....	.....	[1] 1,054	835
Hays, Kans.	5	515	.....	618	781	438
Akron, Colo.	14	.....	762	.....	1,477	1,075
North Platte, Nebr.	12	.....	699	.....	1,103	899
Archer, Wyo.	7	90	702	.....	1,074	893
Jireh, Wyo.	3	.....	740	.....	.....	981
Sheridan, Wyo.	1	.....	880	.....	2,016	1,600
Highmore, S. Dak.	16	.....	1,230	.....	1,223	1,235
Eureka, S. Dak.	8	.....	1,170	.....	1,290	1,309
Cottonwood, S. Dak.	4	.....	966	.....	1,153	1,104
Newell, S. Dak. (dry land)	12	.....	774	.....	910	953
Newell, S. Dak. (irrigated)	8	.....	1,539	.....	1,661	1,652
Hettinger, N. Dak.	2	.....	1,334	.....	1,445	1,285
Dickinson, N. Dak.	13	.....	1,476	.....	1,435	1,522
Williston, N. Dak.	9	.....	1,834	.....	2,121	2,430
Edgeley, N. Dak.	4	.....	1,912	.....	1,976	1,739
Langdon, N. Dak.	3	.....	1,699	.....	1,592	1,821
Brandon, Manitoba	9	.....	2,889	.....	2,712	3,318
Indian Head, Saskatchewan	8	.....	2,695	.....	2,953	3,763
Rosthern, Saskatchewan	1	.....	2,680	.....	3,980	3,645
Lethbridge, Alberta	3	.....	1,643	.....	2,247	2,487
Lacombe, Alberta	4	.....	1,860	[2] 2,445	2,678	2,613
Western Basin and Coast area:						
Modesto, Calif.	3	483	.....	720	[1] 565	[1] 882
Paso Robles, Calif.	1	.....	[1] 2,098	2,893	[1] 3,970	[1] 2,495
Chico, Calif.	3	2,058	.....	.....	[1] 2,587	[1] 1,437
Phoenix, Ariz.	1	3,630	.....	2,970	[1] 3,655	[1] 2,970
Cochise, Ariz.	1	572	.....	633	[1] 989	[1] 296
Prescott, Ariz.	2	.....	.....	211	[1] 120	4
Snowflake, Ariz.	1	560	.....	.....	.....	768
Nephi, Utah	13	1,106	.....	[1] 1,367	989	501
Aberdeen, Idaho	2	787	.....	.....	1,579	1,405
Burns, Oreg.	4	402	649	.....	1,368	1,294
Moro, Oreg.	5	957	736	1,758	2,305	1,678
Lind, Wash.	2	365	.....	604	600	508
Agassiz, British Columbia	5	.....	2,108	.....	2,826	2,360

[1] Sown in fall. [2] Sown in spring. [3] Average for 6 years.

The average yields of the leading varieties of winter emmer, spring emmer, spelt, barley, and oats at 52 experiment stations in the United States and Canada are shown in Table 58, which is a summary of some of the data from the preceding tables. The number of years in which these crops were grown also is shown. At most of the stations only spring varieties of barley and oats were grown, but at a few stations in the southern part of the United States these crops were sown in the fall. Most of the spelt was sown in the fall. Where the barley and oats were sown in the fall or spelt was sown in the spring the fact is indicated by footnotes. The stations are grouped, as heretofore, into four geographic areas, viz, (1) the south Atlantic (humid) area, (2) the Mississippi and St. Lawrence Valleys (subhumid) area, (3) the Great Plains (semiarid) area, and (4) the Western Basin and Coast area.

In the South Atlantic (humid) area barley and oats were more productive than emmer or spelt, except at Arlington Experiment Farm, near Rosslyn, Va., and at College Park, Md. At these points winter spelt considerably exceeded both barley and oats in grain production. The net yields of spelt, considering the weight of free kernels alone, are lower than the yields of winter wheat at these two stations.

In the Mississippi and St. Lawrence Valleys (subhumid) area emmer and spelt were outyielded on the average by the leading varieties of barley and oats, except at St. Paul and Morris, Minn., and Fargo, N. Dak. At St. Paul emmer yielded more than barley but less than oats. At Morris emmer yielded more than oats but less than barley, while at Fargo emmer outyielded both barley and oats. At other stations emmer outyielded both barley and oats in some years.

In the Great Plains (semiarid) area the leading varieties of both barley and oats outyielded emmer and spelt at 15 of the 22 stations where results were obtained. At the remaining 7 stations where one of the two crops, barley or oats, was not well adapted, the other outyielded emmer and spelt. At some stations in some seasons emmer outyielded both barley and oats, and it frequently exceeds the poorer varieties of these crops in yield.

At 3 of the 13 stations in the Western Basin and Coast area, both barley and oats usually outyielded emmer and spelt. At 7 stations either barley or oats (usually barley) outyielded both emmer and spelt. At the 3 remaining stations both barley and oats were outyielded by either emmer or spelt. Of these 3 stations yields were obtained in only two years at Prescott, Ariz., and Lind, Wash., and these yields were very low. At the third station, Nephi, Utah, barley and oats are not well adapted and were outyielded by both emmer and spelt. At all three of these stations winter wheat has produced higher yields of threshed grain than any of the other crops.

Both winter and spring emmer have yielded best when sown at the rate of about 6 to 8 pecks per acre in the sections where these crops are grown.

Winter emmer has produced the highest yields when sown at about the time winter wheat is sown. Spring emmer yields best when sown as early as practicable.

Emmer is most productive when sown with the grain drill at a depth of 1½ to 3 inches.

CONCLUSIONS.

Winter emmer is not hardy enough to be grown on the Great Plains north of Kansas, and even there it may be winterkilled. It is less productive than winter spelt. Because of its low yields it should not be grown in any part of the United States or Canada.

Spring emmer should not be grown except possibly to some extent in North Dakota, eastern South Dakota, and southern Minnesota for the purpose of increasing crop diversification. In all sections of these States it is outyielded, on the average, by the leading varieties of barley or oats, or both, although in some years at some stations it will outyield these crops. Even under conditions where rust and drought are of common occurrence emmer does not compare favorably with barley and oats. Vernal (White Spring or Common) is the best variety of emmer.

Winter spelt is more productive than barley and oats in a limited portion of Maryland and Virginia where experiments have been conducted, and apparently also in central Utah. The limits of its adaptation have not been determined, but it is probable that it will be found to give best results in comparison with other small-grain feed crops in the area between the spring and winter oats and barley areas. It does not produce as high net yields of threshed kernels as does winter wheat, even in those districts where it appears promising.

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